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WYE COLLEGE

Department of Hop Research

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1958

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DEPARTMENTAL STAFF

Head of Department and Entomology

H. S. Darling, B.Sc., M.Agric., A.I.C.T.A., M.I.Biol.

Hop Breeding and Genetics

R. A. Neve, B.Sc., Dip.Agric.Sci.(Cantab.), M.I.Biol.

R. F. Farrar

Field Experimentation

F. C. Thompson, B.Sc., M.Sc.(Agric. Chem.), A.R.I.C.

F. H. Beard, Dip.Hortic.(Wye)

E. G. Cripps, M.Sc., Dip.Agric.(Wye), A.I.C.T.A.

Organic Chemistry

E. W. Weston, B.Sc., A.R.C.S.

Plant Pathology

J. R. Coley-Smith, B.Sc., Ph.D.

Crop Physiology

I. H. Williams, M.Sc., Ph.D.

REVIEW OF RESEARCH

H. S. Darling

As is shown in this report, hop research at Wye College has made satisfactory progress in 1958. In plant breeding work (see page 10) the development of wilt-tolerant varieties to replace the Fuggle has been carried a stage further by field-scale propagation of three promising English-type seedlings of high tolerance short-listed from the Wye/East Malling Joint Scheme. Field propagation of these will continue during 1959 to provide sufficient setts for planting farm trials on three wilt-infected sites in the winter of 1959-60.

The development of polyploid varieties continues. Colchicine treatment was given to six Saaz varieties while tetraploid material isolated from Hallertau plants treated in 1957 was crossed with diploid wilt-tolerant males. It is hoped that this polyploid breeding with foreign varieties may play a significant part in the eventual production of English hops which are suitable for lager beer. Colchicine treatment was also given to selected Mathon material. A stand of mixed triploid seedlings of Bullion was picked by the new College machine with satisfactory results as far as resistance to shattering was concerned.

As described on page 15 the replicated trial of Golding clones planted in 1957 was harvested for the first time as an experiment. In the group of early clones, yields ranged from 19·3 to 24·8 cwt. dried hops per acre. In the late clones yields were heavier, ranging from 23·0 to 28·6 dried cwt. per acre. In each case yield and content of total soft resins appeared to be negatively correlated, the correlation being much more pronounced in the case of the early clones.

Two new three level NPK manurial trials of factorial design were started in Kent and East Sussex. A third is to be laid down in 1959 while the site for a fourth was planted at Wye in March, 1959. Some years must inevitably elapse before reliable results are available from these trials. Meanwhile a summary of recent information on major element deficiencies is given on page 40 while a report on a preliminary long term two-level NPK trial laid down in 1949 has been prepared for publication. The findings of current research

suggest that the phosphate status of the average commercial garden is high enough to permit of satisfactory crop yields from much smaller annual applications of P_2O_5 than are usually given. They also suggest that excessive nitrogenous manuring may be expected to depress yields.

On page 51 details are given of a trial carried out in sand culture to investigate the effect of nitrogenous manuring on the relationship between resins and sugars in the hop cone. This work showed that excessive nitrogen depressed both sugar and resin production and also appeared to reduce the yield of dried cones. While these results are in general conformity with those obtained in large scale manurial trials, it should be noted that under field conditions, the observed effect of manurial treatments on the resin content of the cones may be too small and too variable to have any commercial significance.

Research on systemic insecticides is discussed on page 24. In a replicated trial on Goldings, dimefox and demeton methyl were compared using a derris spray treatment as a standard. Both systemic compounds were soil applied and gave excellent control of a light attack of Hop Aphis. The dimefox treatment significantly outyielded derris by 3·41 cwt. of dried hops per acre and also outyielded demeton methyl by 1·67 dried cwt. The latter difference approached statistical significance at $P=0·05$ and did not appear to be due to superior insecticidal ability on the part of dimefox.

Work on Hop Downy Mildew is gathering momentum following its recommencement in 1955, and has at present two main objectives. The first is to discover how the fungus overwinters and appears as primary infections in the form of basal spikes in the spring. The second is to develop reliable methods for estimating the levels of resistance to the disease in different varieties to assist plant breeding research on the production of resistant seedlings.

A review of existing knowledge on the overwintering of the fungus is given in Appendix V on page 88. The possibility of controlling the basal spike form of Downy Mildew by dusting the soil over the crown of each hill with fungicides during the growing season is under investigation at Wye and is discussed on page 28. New setts planted in an old garden were used in this trial and no results were obtained from the treatments in 1958, all remaining disease-free. It may be mentioned that positive results have since been obtained and will be discussed in the report for 1959.

The possibility of controlling basal spike formation by applying agricultural grade streptomycin to the crown of each hill in the

spring was also investigated. Goldings were used in this trial in which, contrary to recent findings in America, no control of basal spike was obtained.

Hops grown during the winter under glass were used in the development of methods for estimating the resistance of leaf material to infection by Downy Mildew under laboratory conditions. They were also used for research on oospore formation in which the antheridial stage of the Downy Mildew fungus was observed for the first time in this country.

Studies on the growth of hop plants which were initiated in 1957 have continued and are briefly mentioned on page 31. This work is essentially of a long term nature and results are not yet completed in many aspects. Research on the related problem of food storage in the hop plant has made progress and the results obtained are given in an article on page 55. They show that the onset of dormancy is accompanied by the building up of a relatively large storage organ by a small leaf area. Where dormancy is prevented by suitable manipulation of light and temperature little food accumulation occurs in spite of the development of a large leaf area.

Studies on hop propagation are discussed in an article on page 62. This work has shown that by using mist and soil-warming techniques and artificial illumination when necessary, large numbers of cuttings can be rooted quickly and safely even in midwinter. By this means a rapid succession of batches of standard plants has been provided for research on disease resistance and other problems throughout the year.

In collaboration with Guinness Hop Farms Ltd. a replicated field-scale irrigation experiment was attempted at Bodiam, Sussex, using a mature stand of Fuggle hops. Owing to the very wet summer of 1958, only limited data were obtained. This experiment is being repeated in 1959 when it is hoped that climatic conditions may favour the expression of clear cut results.

Staff of the National Institute of Agricultural Engineering have used the experimental kilns at the College for further investigations on the problems inherent in the performance of continuous driers of advanced design. It is hoped that the results of these investigations will be summarized in a short paper to be published in the departmental report for 1959. The N.I.A.E. have also collaborated with Wye staff in preliminary observations on the mechanical harvesting of small experimental plots using the new College machine, a medium-sized, near standard commercial model. The

results obtained in 1958 were not discouraging and this work is to be continued and extended in 1959.

As in previous years, this report includes appendices on matters related to hop research at Wye College. Thanks are expressed to the Ministry of Agriculture, Fisheries and Food for permission to publish Appendices III and IV in which Mr. Chater and Miss Jary of the National Agricultural Advisory Service discuss the 1958 hop season in the West Midland and South-Eastern Regions respectively.

Among the points of interest contained in these appendices will be noted the fact that over 80 per cent. of the 1958 West Midland hop acreage was picked by machine. Mechanically minded growers will also note the appearance of a prototype spinner designed to remove the earth from hop crowns prior to dressing.

The apparently successful suppression of the Progressive Wilt outbreak at Rosemaund Experimental Husbandry Farm, Hereford, will be noted with satisfaction. With less satisfaction it will be noted that in the South-east more than 260 farms are now known to be infected with Progressive Wilt. While new outbreaks continue to be reported and suppressed in the clean areas of North and East Kent, the incidence of infection within the main wilt area is increasing. The production of wilt-sensitive varieties on many infected farms is no longer economic and the area under tolerant varieties has risen to 1300 acres or nearly 10 per cent. of the total acreage in the South-east.

In Appendix II, Mr. Pocock of Nottingham University follows his contribution in last year's report on changes in hop acreage in the South-east over the past 150 years with a similar study on the West Midland hop industry. It is clear that while changes in the West Midland hop acreage have occurred during the past century, they have been smaller and much less pronounced than in the South-east.

In addition to its work on English hop problems, Wye College has shared in discussions on European hop research through the Scientific Commission of the European Hops Cultivation Committee and through a newly-formed Liaison Committee on which the Scientific Commission and the European Brewery Convention are jointly represented. The Scientific Commission met in full session at Brussels in July, 1958, while the Liaison Committee met at Rotterdam in February, 1959. The College was represented at both these meetings.

Wye College has maintained its essential contacts during the

year with the English Hop Industry through the appropriate committees and other channels of the Hops Marketing Board, the Institute of Brewing, the National Agricultural Advisory Service and the Association of Growers of the New Varieties of Hops, as well as by personal links with growers. Staff have attended meetings of the Hops Working Party and the Rosemaund Farm Advisory Committee and have also given lectures on their work to conferences and meetings of growers and to other interested bodies.

Thanks are expressed to the National Institute of Agricultural Engineering, to East Malling Research Station and to the Brewing Industry Research Foundation for co-operation enjoyed during the year. Thanks are also due to growers, factors, merchants and other friends of the College who have helped in departmental research.

As mentioned on page 7 grateful acknowledgements are due to the National Agricultural Advisory Service and to the National Institute of Agricultural Botany for help received in the establishment and maintenance of quarantine gardens and out-stations in the Stratford-on-Avon and Cambridge areas. Once again thanks are expressed to Dr. H. H. Glasscock, Regional Plant Pathologist, N.A.A.S., Wye, for help in examining departmental material for wilt infection, and in advising on research on Downy Mildew Disease.

QUARANTINE GARDENS AND OUTSTATIONS

H. S. Darling

Following the 1954-55 outbreak of Progressive *Verticillium* Wilt at Wye, the Department of Hop Research established three hop quarantine gardens in the Cambridge area as described in previous reports (Darling, 1957; 1958). Two of these gardens were sited at Cuckoo Pastures Experimental Husbandry Farm (National Agricultural Advisory Service), Boxworth, and the remaining one on the land of the National Institute of Agricultural Botany at Lolworth. The Boxworth gardens were planted with material of known worth including the departmental plant breeding collection. The Lolworth garden was planted with incompletely assessed seedling material bred by Professor Salmon.

In March, 1958, the departmental plant breeding collection was established in two gardens at Luddington Experimental Horticulture Station (N.A.A.S.), near Stratford-on-Avon, with setts from Boxworth. This material was originally moved to Boxworth in March, 1956, from wilt-free gardens at Wye. It remained free from all symptoms of wilt during 1956 and 1957. In the winter of 1957-58 laboratory examination of the setts by the N.A.A.S. before planting at Luddington failed to reveal any infection by *Verticillium albo-atrum.*

The new plants at Luddington have made satisfactory growth, and both they and the parent hills at Boxworth remained free from wilt symptoms during 1958. It may be concluded that this valuable plant breeding collection has been safely established on a permanent basis at Luddington in a wilt-free condition. This has been made possible only by the quarantine procedure adopted following the 1954-55 wilt outbreak at Wye. It should be noted that the varieties now at Luddington include material of the Fuggle and Golding clones which are at present undergoing further selection at Wye.

Following the successful moving of this plant breeding material to Luddington, the quarantine garden area at Boxworth has been reduced to the minimum necessary for the routine requirements of

the Department. Subject to the approval of the N.A.A.S. this minimum area will be maintained at Boxworth until such time as the College farm is set free from the present restrictions imposed under the Progressive Wilt Order.

The quarantine garden on the land of the National Institute of Agricultural Botany at Lolworth, Cambridge, made good growth during 1958. This garden was established in March, 1957, with seedling material from the eastern half of Wye Field Garden (the garden in which the wilt outbreak occurred). The plants at Lolworth remained free from wilt symptoms during 1957 and 1958 and in the winter of 1958-59 selected material of value was brought back to Wye for use in plant breeding research. Before being planted at Wye this material was subjected to laboratory examination by the N.A.A.S. which failed to reveal any infection by *V. albo-atrum*. The unwanted plants remaining at Lolworth were grubbed and this garden, having served its purpose, was closed down in November, 1958.

This opportunity is taken to express the deep indebtedness of the College to the N.A.A.S. and the N.I.A.B. for their generous co-operation and help in the establishment and running of these quarantine gardens and out-stations.

With the establishment of the plant breeding collection at Luddington and the successful return of the Lolworth material to Wye, future quarantine garden activity may be expected to be on a much smaller scale than in recent years. In view of this, discussion of the subject in future reports will be confined to the annual review of the work of the Plant Breeding Section.

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REVIEW OF THE 1958 HOP SEASON AT WYE COLLEGE

H. S. Darling

The 1958 growing season while not cold, was very wet with low figures for sunshine. Plant growth and development were good and a large crop was formed during August. September was warm and sunny, allowing the cones to ripen and complete their development under favourable conditions. Crop yields and resin content were both higher than in 1957. Meteorological data for Wye for April-September, 1958, are tabulated below; average values for the 24 year period 1935-58 are given for comparison.

	Rainfall Inches per month		Sunshine Hours per day		Mean Temperature °F.	
	1958	1935-58	1958	1935-58	1958	1935-58
April	1·67	1·56	5·06	5·90	44·8	47·5
May	2·16	1·96	6·16	6·95	53·0	52·9
June	4·75	1·83	5·42	7·38	57·5	58·7
July	1·86	2·23	6·60	6·71	61·3	61·8
August ..	4·13	2·65	3·69	6·24	61·2	61·7
September ..	3·80	2·43	5·17	5·01	60·5	58·0

Aphis attack was light and easily controlled. No attack by red spider was observed. Mould was kept in check by applications of sulphur. The mild, wet summer weather favoured Downy Mildew Disease which was potentially serious; it was controlled satisfactorily by spiking and by copper sprays.

No further cases of *Verticillium albo-atrum* in hops at Wye have been recorded. Wye Field, in which the 1954-55 outbreak occurred, is under permanent grass, having become the College sports ground.

Hop picking started on September 8th and ended on September 26th with a total of 16 picking days. The number of hand pickers available in 1958 was less than in 1957, and was barely sufficient for the present reduced College acreage. While every effort will be

made to maintain, and if possible increase the number of hand pickers, the College has accepted the fact that hand picking for the crop as a whole is no longer possible. A medium-sized picking machine was installed at Silks Farm and was used experimentally to pick part of the 1958 College crop.

The hops weighed badly on drying giving an average ratio of 125 green bushels per dried cwt. The total yield as weighed at the oast after drying was 144·5 cwt. Details, together with comparable data for 1957 are given below:

	1958	*1957*
Goldings	67·0 cwt.	52·5 cwt.
Fuggle N	4·5 „	—
Northern Brewer ..	7·0 „	—
Bullion	10·5 „	—
Plant breeding hops	55·5 „	94·0 „
	144·5 cwt.	146·5 cwt.

The welcome appearance of Fuggle N, Northern Brewer and Bullion on the list of College varieties results from planting in March, 1958, in the southern half of Withersdane Garden for a new height of wirework and spacing trial. The yield of Goldings from Silks Garden, where the acreage of plant is unchanged, has risen as the field trial of Golding clones, planted in March, 1957, has come into bearing.

The grubbing of the nursery and variety trial plots in Wye Field in 1957 has greatly cut down the total yield of plant breeding hops. The re-establishment of these plots in the new Withersdane Garden will take place over a number of years commencing in March, 1959. Meanwhile the area of plant breeding hops has suffered a further temporary reduction in the loss of the Acre Piece of the Nursery Garden which was grubbed in December, 1958, and handed over to the Horticultural Department of the College.

The crop valued well. All the named varieties were sold at Grade I or Grade I plus bonus prices.

PLANT BREEDING SECTION

REVIEW OF THE YEAR'S WORK

R. A. Neve and R. F. Farrar

The work of the section can be broadly divided into two categories, the first being the production of improved varieties, and the second the collection of genetic and other information which may in time make possible more efficient planning of the breeding programme. Progress during the season is discussed below under the two headings of Breeding Programme and Research Programme.

In some fields there is considerable overlap between the two programmes. For example, the use of polyploidy in the breeding programme is now well established, nevertheless a considerable amount of research remains to be carried out into the characteristics of polyploid hops, and further possible applications of the method to the breeding programme.

In planning the work of the section the practical problem of producing new varieties has first priority, and the research programme has to be fitted in with this. In general, the limitations which this imposes are few, but an important exception is in research on Progressive Wilt. The present method for testing the reaction of seedlings to this disease is so cumbersome that the facilities available at East Malling are largely occupied in testing selected new varieties. If plant breeding is to provide an effective answer to the wilt problem, some fundamental information must be obtained on the sources of wilt tolerance, and the way tolerance is inherited. A start was made during the year, as described below, to investigate a method of field-testing whole seedling families in their second year. While this promises to be of considerable value it is hoped that a quicker and more reliable glasshouse or laboratory technique will soon be developed which should make possible more rapid advances in research on the inheritance of wilt tolerance.

The valuable collection of hop varieties from many parts of the world and the Fuggle and Golding clonal selections were established at Luddington with considerable success. Only a few varieties failed

to grow and additional material was taken from Boxworth to make good these failures. As a result of this move it was possible to close down part of the quarantine garden area at Boxworth. The garden at Lolworth which had fulfilled its quarantine function was also closed down after all the selected material had been transferred back to Wye. All the material moved from these gardens was examined by the Advisory Pathologist, N.A.A.S., and no *Verticillium albo-atrum* was detected. The remaining garden area at Boxworth has been retained to serve as a site for quarantining varieties that it is wished to send out from Wye in the near future.

Breeding Programme

The production of wilt tolerant hops to replace existing English varieties—and Fuggle in particular—has had first priority in the breeding programme since 1950 and there is now material at all stages of selection. The most advanced material is that of the Wye/East Malling Joint Scheme from which three varieties are being propagated for the establishment of farm trials in the winter of 1959-60, one of the four varieties selected in 1957 having been rejected as a result of small scale brewing trials carried out at the Brewing Industry Research Foundation.

A meeting was held at East Malling Research Station in January, 1958, when staff from Wye, East Malling and the National Agricultural Advisory Service discussed the arrangements for these farm trials, with the three growers who have undertaken to provide sites. It was agreed that each site should contain a 400 hill plot of each of the three varieties from the Scheme, and a similar plot of Whitbread's Golding Variety as a control.

The remaining varieties in the Scheme were reduced to 26, four being rejected for cultural reasons. One of these was from the group of four American type varieties which had been selected for further investigation.

The next series of seedlings bred for potential wilt tolerance are triploids, and from this group 22 seedlings of Bullion and 38 seedlings of Fuggle have been provisionally selected, and are being propagated for wilt testing.

Following on after these families are many diploid and triploid seedlings of Fuggles and Goldings from which initial selections have not yet been made. These total some 3,000, of which nearly 2,000 were raised and planted out during the year.

In continuation of the same programme, diploid and tetraploid Eastwell Golding and Early Bird were pollinated in 1958 by

three wilt tolerant males not previously used in crosses involving Golding females.

The demand for hops for lager brewing was discussed in last year's Annual Report (Neve, 1958) and as part of a programme to meet this demand crosses were made between diploid Hallertau, tetraploid Hallertau and diploid Saaz, and wilt tolerant males.

To meet the demand for improved wilt susceptible varieties from growers outside the wilt area, seedlings from the various families mentioned above which look promising will not be discarded if they prove to be susceptible to Progressive Wilt. Moreover, with a view to providing varieties specifically for the wilt-free areas, a start has been made with the use of male parents that are more likely to transmit good brewing characteristics than are the wilt tolerant males so far available. During the year seedlings from the cross between Fuggle N and male 169—itself a seedling of Fuggle and an English male—were raised and planted out. Male 169 was recorded by Professor Salmon as being very susceptible to mould, and more than a quarter of these seedlings were heavily attacked by this disease. No similar attacks were recorded in any other families. A German male (T47) was used to pollinate tetraploid forms of Eastwell Golding, Early Bird and Hallertau.

Since many mosaic sensitive varieties are grown in the wilt free areas, there may be a place for mosaic sensitive seedling varieties to be grown in proximity to them. A start was made with graft-testing cuttings of Golding seedlings to determine their reaction to this virus before the plants became naturally infected and lost. A small isolated garden of about 200 hills is used to plant out some of the Golding seedlings, and the incidence of mosaic in this garden is very low compared with similar seedlings in the mosaic carrier garden.

Resistance to Downy Mildew is another quality sought after in the breeding programme and three varieties obtained from Dr. Zattler in Germany are used as the source of resistance. Seedling plants from crosses between the Zattler varieties and wilt tolerant males were inoculated with Downy Mildew in the four leaf stage to test their resistance, and seedlings which survived a similar test in 1957 were further tested by leaf and bud inoculation in 1958. Three male seedlings showing some resistance have been selected for use as male parents for further breeding work.

Some seventy hills of various triploid seedlings of Bullion were picked by machine with very promising results. Samples of these hops were demonstrated at the New Varieties Exhibition.

Tetraploid material of the Hallertau variety was isolated from plants treated with colchicine in 1957, and treatment was started on six Saaz varieties and the variety Mathon.

Research Programme

An experimental wilt tolerance test was carried out at East Malling in which the plant material was obtained by layering seedling hops in their first year, the basal set and two layer cuttings of each seedling being sent for test. The remaining cuttings were grown at Wye. The losses from causes other than Progressive Wilt were sufficiently low for the trial to be successful. It is intended to use this technique for a series of tests designed to yield genetic information on the inheritance of wilt tolerance. In preparation for such a test in 1959, diploid and triploid seedlings of the same parentage were layered in their first year. Comparison of the results should indicate any difference in the transmission of wilt tolerance at the diploid and triploid level.

Investigations into the seed content of triploid hops were continued and it is evident that considerable variations occur from season to season. Present work is aimed at discovering whether these variations are due to changes within the plant such as ageing, or to external conditions, such as climate.

Resin analyses were made on plants chosen at random from four seedling families in an attempt to elucidate the manner in which resin characters are inherited. The results, though inconclusive, suggested that the comparison of diploid and triploid seedlings on a larger scale might yield valuable information. In support of the resin analyses, the seed content of each sample was also determined by the oven drying method (Burgess, 1925) in order to assess the correction necessitated by the widely differing amounts of seed. The average seed contents of the four families of seedlings, which were in their second year, were:

Family 11/56. Triploid seedlings of 4x Eastwell Golding × 321
3·3% seed.

„ 12/56. „ „ „ 4x Eastwell Golding × 1161
4·4% seed.

„ 14/56. Diploid „ „ 2x Eastwell Golding × 321
18·8% seed.

„ 15/56. „ „ „ 2x Fuggle × 321
22·1% seed.

Recording of seedling families confirmed that the proportion of male seedlings depends upon the amount of pollen applied when pollinating and use was made of this fact when making crosses. Diploid male seedlings may be of value for further breeding work, but triploid males are valueless because they are sterile and it is, therefore, desirable to keep the number of males in triploid families as low as possible to avoid wasting space in the garden.

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FIELD EXPERIMENTATION SECTION

REVIEW OF THE YEAR'S WORK

F. C. Thompson, F. H. Beard and E. G. Cripps

General

The section has continued to assist the Head of the Department in the general management of the commercially grown hops at Wye. An account of the growth of the crop from this aspect, is given on page 8.

Extramural activities have included lectures by Mr. Thompson on growing hops for machine picking (N.F.U. Hop Growers' Conference, Maidstone) and on hop manuring (East Sussex County Council Course on Hop Growing, Robertsbridge). As part of the latter course, Mr. Beard lectured on hop propagation.

Mr. Thompson continued to serve as a member of the Hops Working Party of the National Agricultural Advisory Service and of the Scientific Commission of the European Hops Culture Committee. He represented the Scientific Commission at a meeting of the European Brewery Convention Hops Liaison Committee, held in Rotterdam, in February, 1959.

Height of Wirework and Spacing Trial

This trial was planted on light polework in the spring of 1958, all three varieties under test (Fuggle N, Northern Brewer and Bullion) being successfully established. The wirework, providing for the testing of three heights, 14 ft., 16 ft. and 18 ft., has now been erected.

The Testing and Selection of Fuggle and Golding Clones

The trial of selected Golding and Golding Variety clones, established in 1957, was harvested in plots in 1958.

Among the early clones (Early Birds and Bramlings) there was a highly significant negative correlation between yield and resin content (observed values ranged from 19·3 to 24·8 dried cwt./acre

and from 11·8 per cent. to 18·83 per cent. Total Soft Resins), indicating the difficulties inherent in selecting a clone possessing both high yield and high resin characteristics. On market valuation there was little to choose between the clones on appearance; on aroma slight preferences were expressed, which were not related to resin content.

With the later clones, though there was a small negative correlation between yield and resin content (observed values ranged from 23 to 28·6 dried cwt./acre and from 11·52 per cent. to 14·13 per cent. Total Soft Resins), this did not approach significance. The lower resin content of these later clones relative to the early ones was unexpected. It is possible that harvesting took place before the cones had developed their maximum resin content, although to the eye and hand they appeared normally ripe when picked. On market valuation, stronger preferences were expressed for certain of the later clones, than occurred in the case of the early clones. These preferences bore no consistent relation to yield or resin content.

A new randomized trial of selected Fuggle clones was established in the new Withersdane garden in March, 1959.

Manurial Trials

In 1958, records of plot yields were taken from the long term 2^2, NPKMg trial at Bodiam, Sussex (Thompson, 1955), which it had not been possible to harvest since 1955, though the different treatments had been applied annually throughout the intervening period. The results obtained from the phosphate treatments were of particular interest; the P_2 plots which had received no phosphate other than that in a 14 ton per acre dressing of dung for a five year period, gave virtually the same yield as the P_1 plots which had received 10 cwt. per acre superphosphate plus dung annually, over the same period. At the commencement of these treatments, the soil on the P_2 plots contained a very high level of available phosphate (8·0 p.p.m. P in a 2/1 extract of the soil in Morgan's reagent), whereas the soil on the P_1 plots was classified as medium high (4·2 p.p.m. available P). By 1957 the soil on both series of plots had risen to over 11·0 p.p.m. available P, the increase on the P_2 plots being, presumably, due to the phosphate in the annual dressings of dung. It would appear, therefore, that this small annual application of organic phosphate has been ample to maintain yield, on a soil initially very high in available phosphate. High potash depressed yield appreciably in 1958, and there was evidence that this was

partly due to antagonism between potassium and magnesium—there was an appreciable response to applied magnesium at the low potash level but a negligible response at the high potash level. A full report on the 10-year period covered by this trial has been prepared for publication.

Differential manurial treatments were applied, in 1958, to two new 3^3 NPK trials, which were run as uniformity trials in 1957. Records of crop yields were taken and plot variability was found to be high at both centres, and appreciably more than in 1957. No statistically significant differences were found and there was no significant correlation between the 1957 and 1958 data. On one of the sites, at Teynham, Kent, on a soil very high in both available phosphate and potash, the medium levels of nitrogen and potash manuring and the lowest level of phosphate, gave the highest yields. This negative response to high phosphate is of interest, in view of the heavy phosphatic manuring commonly given to commercially grown hops. On the second site, at Bodiam, Sussex, there was no evidence of any consistent trends in response to the different manurial treatments.

A site was selected at Bodiam, Sussex, for a third 3^3 NPK trial, and the plots were marked out and harvested as a uniformity trial. The variability found in yield (S.E. per plot, 13 per cent.) was disappointingly high, although plant growth on the site appeared reasonably uniform, when assessed before harvesting. Nevertheless, in view of the difficulties in obtaining satisfactory sites for field trials in commercial gardens, it was decided to proceed with this trial in 1959.

Leaf and soil samples for mineral nutrient analysis, and cone samples for resin analysis, were collected from all the trial plots, as in previous years. The use of soil analysis in interpreting yield response to manurial treatments has been found to be of value and the soil data is, in general, supported by leaf analysis. The usefulness of the latter, however, is hampered by the effect of luxury consumption, resulting in high values for leaf mineral content with heavy manuring, which may nevertheless be associated with reduced crop yield.

Resin analysis has confirmed the view that under normal field conditions, different manurial treatments have no marked effect on the resin content of hop cones (Thompson, *loc. cit.*). Furthermore, the range of variation found in experiments harvested as uniformity trials in 1957, was of a similar order to that found after differential manurial treatments had been applied in 1958.

A small observation trial, to test the effect on hop quality of soil and spray applications of magnesium sulphate, on a site in a commercial garden where the hops showed marked symptoms of magnesium deficiency, gave largely negative results. In spite of the widely-held view that magnesium nutrition affects hop quality, market assessment of samples from the observation plots showed a slight preference for the "no-magnesium" treatment. Hops from the plot receiving a soil application of 10 cwt. per acre Epsom salts did, however, show a slightly higher resin content. This trial is being continued for a further year to see if the 1958 findings are confirmed.

The mineral deficiency plots at Goudhurst, Kent, were maintained and a report on the results obtained from these plots is given on page 40.

A report on the leaf analysis data from the hop manurial trial at the Rosemaund Experimental Farm, has been prepared for publication in the full report of the Rosemaund hop experiments which is to appear in 1959.

The observation trial on the growth of hops in grass at Bodiam, Sussex, was maintained, and in the wet season of 1958 produced satisfactory growth and crop yield.

Copper Fungicide Deposits on Leaves

In 1958 two rates of spray application were tested, namely, 50 and 150 gallons per acre, both sprays supplying the same dosage of copper per acre as copper oxychloride. Leaf samples, for analysis, were taken throughout the season from a fixed position on the plant, and the results obtained supported the 1957 findings that the amount of copper deposited, per unit area of leaf, increased with increase in volume of spray applied. It should be noted that the smaller deposits resulting from low volume applications gave effective control of Downy Mildew.

Reference

Thompson, F. C. (1955). A long-term manurial trial on hops. Progress report, 1954. *Rep. Dep. Hop Res. Wye Coll. for 1954*, 64.

ORGANIC CHEMISTRY SECTION

REVIEW OF THE YEAR'S WORK

E. W. Weston

Systemic Chemicals

Introduction

The main purpose of these studies was to examine the effects upon the metabolism of the hop plant, of certain systemic chemicals. Their effect on the incidence of a common fungal disease of the hop, Downy Mildew (*Pseudoperonospora humuli*), was also noted and the severity of attack measured as far as possible.

The particular systemic compounds chosen were chemically closely related to certain growth regulating compounds of which 2:4 D is probably the best known and the most active.

The chemicals were:

3:5-dichlorophenoxyacetic acid,	Code No. 35ClPOA
2:4:6-trichlorophenoxyacetic acid,	,, ,, 246ClPOA
pentachlorophenoxyacetic acid,	,, ,, 23456ClPOA
α(2-chlorophenylthio)propionic acid,	,, ,, 2ClPSP

Although the chemical structures of these compounds were so closely related to growth regulating substances, they were themselves for various reasons related to their chemical structure (Wain, 1956) either inactive or very slightly active. They have been shown, however, to possess some fungicidal properties. Tests of their fungicidal activity (Fawcett, Spencer and Wain, 1957) indicated that such activity within the growing plant was greater than would be accounted for by their activity *in vitro*. This increased *in vivo* activity may be the result of a modification of the systemic molecule or a change in the plant's normal metabolism and may express itself in varying degrees in different plants or even different varieties of the same plant.

Experimental

The variety used was clonal Fuggle N, 72 cuttings being planted out in early spring in a small isolated garden in which spray

treatments could be controlled. By the beginning of July the plants had made good growth and the best 60 plants were selected for the experiment.

The chemicals to be sprayed were dissolved by shaking with water and a calculated quantity of sodium hydroxide. If the chemical had not dissolved after an hour's mechanical shaking, a further drop of sodium hydroxide solution was added and shaking continued. This process was repeated until all the chemical had been neutralized and dissolved. The solution was diluted to give a concentration of 500 p.p.m. in each case and a few drops of Agral wetting agent was added to each solution to ensure rapid uptake by the leaf.

The plants were allocated at random to five groups, each of four groups receiving one of the chemical sprays while the fifth group was left unsprayed as a control. The twelve plants receiving a particular spray required approximately a litre of solution in order to wet all leaves to run-off and the spraying was most easily carried out by means of a pneumatic hand sprayer of this capacity. Some time later, eight of each group of twelve plants was sprayed again with the particular solution used for the first spraying and two days after this four of the eight plants were sprayed again.

Analysis

Two weeks after the final spraying, samples of main bine leaves were taken from each plant, the leaves selected being from the middle of the bine. These were dried rapidly in a vacuum desiccator oven at 40° C., the drying being promoted by sandwiching the leaf samples between muslin bags containing silica gel. When dry the leaves were finely ground with a pestle and mortar and stored until required for analysis.

The mature hops were picked during the second week of September and the yield of each plant was weighed after drying. The drying was carried out in experimental kilns, each sample being contained in a muslin bag. The drying temperature was maintained at 140° F. but sulphur treatment which is used commercially was omitted. After drying, the hops were allowed to cool in the muslin bags and then packed for storage in polythene bags.

Both leaf and cone samples were analysed for the elements nitrogen, phosphorus, potassium, calcium, magnesium, and manganese, and for reducing sugars, while the cone samples were analysed for resin content in addition.

During growth any "spikes" formed by Downy Mildew were

removed and counted. No distinction was made between terminal and lateral spikes.

The results of these analyses and observations are shown in Table 1.

Conclusions

None of the spray treatments had any significant effect upon the number of Downy Mildew spikes formed, treatment 23456ClPOA showing the least, and 2ClPSP showing the most and slightly more than the control. 2ClPSP also caused a highly significant drop in the dry weight yield and a highly significant drop in the percentage of α-acids. 23456ClPOA was the only treatment to give higher values than the control in either of these respects although neither was significant.

2ClPSP caused a significant increase of calcium, magnesium, and manganese in the hop cone, but otherwise caused no significant change in any other element in the cones or the leaves. 246ClPOA caused a highly significant increase in the calcium content of cones but no other significant change. Neither 23456ClPOA or 35ClPOA caused any significant change in any element in hop leaf or cone.

Examination of Dimefox-Treated Hop Plants

Certain new hop varieties have been shown to be susceptible to damage from the widely used systemic insecticide dimefox (bis dimethylaminofluorophosphine oxide). This was first noted in 1955 when the chemical was used on unnamed plant breeding material growing as cuttings in propagation rows (Darling and Derbyshire, 1956). It was confirmed the following year with mature hills of the more susceptible of these unnamed varieties (Neve and Farrar, 1957). It was apparent in the first instance that susceptibility to damage was varietal, since there was a number of plants in each of the clones treated and the observation was therefore replicated. It may be noted that in 1955 the application was at the reduced rate of 0·15 gm. dimefox in 70 ml. water poured on the rootstock of each young plant; the recommended commercial dose being 0·25 gm. in 120 ml. water for plants of the same age.

The nature of the difference between varieties susceptible to dimefox toxicity and those resistant to toxicity is obscure, but there are at least three possibilities which may account for the difference. One possibility is that susceptible plants take up more dimefox than the resistant plants. A second possibility is that the resistant plants

TABLE I

EFFECTS OF SYSTEMIC CHEMICALS UPON HOP GROWTH

(Values given as mean per plant)

	Control	2ClPSP	23456-ClPOA	35-ClPOA	246-ClPOA	Significant deviations	
						5%	1%
Yield of dried cones (gm.) ..	75	32	81	57	52		
Deviation from control ..		−43	6	−18	−23	29·7	40·4
Mean Downy Mildew spikes/plant	7·8	9·2	5·0	7·4	6·0		
Deviation from control ..		1·4	−2·8	−0·4	−1·8	4·4	6·0
%alpha acids ..	2·73	1·83	2·89	2·68	2·63		
Deviation from control ..		−0·90	0·16	−0·05	−0·10	0·45	0·61
%beta fraction	4·60	4·47	4·92	4·65	4·56		
Deviation from control ..		−0·13	0·32	0·05	−0·04	0·51	0·69
%reducing sugars in hop leaf	2·26	2·40	2·51	2·07	1·82		
Deviation from control ..		0·14	0·25	−0·19	−0·44	0·59	0·80
%reducing sugars in hop cone	3·03	3·61	2·55	2·79	2·80		
Deviation from control ..		0·58	−0·48	−0·24	−0·23	0·51	0·69
%Nitrogen in hop leaf ..	3·49	3·50	3·47	3·36	3·40		
Deviation from control ..		0·01	−0·02	−0·13	−0·09	0·48	0·65
%Nitrogen in hop cone ..	3·93	3·75	4·02	3·78	3·89		
Deviation from control ..		−0·18	0·09	−0·15	−0·04	0·25	0·34
%Phosphorus in hop leaf ..	0·600	0·585	0·584	0·666	0·006		
Deviation from control ..		−0·015	−0·016	0·066	0·606	0·108	0·147
%Phosphorus in hop cone ..	0·746	0·773	0·731	0·769	0·778		
Deviation from control ..		0·027	−0·015	0·023	0·032	0·051	0·069
%Potassium in hop leaf ..	1·93	2·16	2·02	1·91	1·80		
Deviation from control ..		0·23	0·09	−0·02	−0·13	0·46	0·62
%Potassium in hop cone ..	2·88	2·78	2·90	2·92	2·91		
Deviation from control ..		−0·10	0·02	0·04	0·03	0·16	0·22
%Calcium in hop leaf ..	5·91	5·69	5·82	6·21	6·21		
Deviation from control ..		−0·22	−0·09	0·30	0·30	0·78	1·06
%Calcium in hop cone ..	7·18	8·98	7·98	7·92	8·83		
Deviation from control ..		1·80	0·80	0·74	1·65	1·19	1·61
%Magnesium in hop leaf	0·888	0·754	0·839	0·895	0·936		
Deviation from control ..		−0·134	−0·049	0·007	0·048	0·25	0·34
%Magnesium in hop cone ..	0·312	0·344	0·302	0·318	0·320		
Deviation from control ..		0·032	−0·010	0·006	0·008	0·032	0·044
p.p.m. Manganese in hop leaf	234	204	248	313	277		
Deviation from control ..		−30	14	79	43	83	113
p.p.m. Manganese in hop cone	124	174	150	136	144		
Deviation from control ..		50	26	12	20	47	63

decompose dimefox into non-phytotoxic compounds more rapidly than susceptible plants. A third possibility is that different varieties may form different partial decomposition products from dimefox and that it is these products that include the toxic factors.

A preliminary experiment was carried out in 1958, using two dimefox-susceptible varieties and a control resistant variety, to examine quantitatively the uptake of dimefox by analysing leaves according to the technique described by Field and Laws (1957). Owing to the very variable nature of the data obtained no definite conclusions can yet be drawn. The problem will be examined further in 1959.

Resin Analyses

Resin analyses have been carried out on the 1958 crop on behalf of other organizations as well as for current research within the Department, in addition to those listed above.

These have been as follows:

Institute of Brewing Challenge Cups ..	84 samples
Rosemaund Expt. Farm Trials	105 ,,
Hop Dept. Plant Breeding Trials ..	261 ,,
Hop Dept. Cultural and Manurial ..	163 ,,
Miscellaneous	42 ,,
Total	655 ,,

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ENTOMOLOGY SECTION

REVIEW OF THE YEAR'S WORK

H. S. Darling and F. H. Beard

(*a*) Systemic Insecticides and Control of the Hop Aphis

An insecticide trial was carried out to compare systemic and non-systemic insecticides in the control of the Hop Aphis (*Phorodon humuli*) and in their effect on crop yield and on the ratio of green to dried hops. A mature stand of Petham Golding hops was used, grown on the square at 6 ft. 6 in. (2 metres) spacing, with upright umbrella stringing on wirework 14 ft. 6 in. (4·5 metres) high.

Three insecticidal treatments were applied as follows:

Dimefox (systemic)

Demeton methyl (systemic)

Derris (non-systemic).

The treatments were replicated five times involving a total of 450 hills. Each plot consisted of 30 hills of which 12 were recorded and 18 were discards. The derris was applied nine times at approximately weekly intervals from June 6th to August 14th as a spray by means of a small motor sprayer and a hand lance. Both systemic compounds were soil-applied in water at 120 ml. per hill. There were two applications of Dimefox, one at 0·5 gm. per hill on June 6th and one at 0·25 gm. per hill on July 18th. Demeton methyl was applied three times at 0·25 gm. per hill on June 5th and 27th and July 15th.

Attack by the Hop Aphis at Wye in 1958 began in the last week of May. It continued until late July but was never more than moderate in intensity. For much of the year it was light to very light. Counts were made throughout the season of leaves showing infestations of later stage nymphs and wingless adults. On June 5th all treatments showed 100 per cent. leaves infested though the overall number of aphides per leaf was small. The application of the treatments from June 6th onwards greatly reduced infestations especially where systemic insecticides were used. The following

results were obtained from leaf counts made during June, July and August:

Date of Count	Percentage of leaves infested		
	Dimefox	Demeton methyl	Derris
June 5th	100	100	100
June 11th	0	2	58
June 18th	0	0	45
June 25th	1	9	58
July 3rd	1	2	55
July 9th	1	1	50
July 15th	5	0	50
August 7th	0	0	0
August 13th	0	0	0
Mean for June and July	1·3	2·3	52·7

The counts up to and including July 3rd were made on 100 leaves per treatment selected at random from all plots at up to 8 ft. 6 in. (2·5 metres) above ground level. From July 9th onwards the leaves examined were at the level of the top wire, i.e. 14 ft. 6 in. (4·5 metres) above ground level. The numbers of aphides per leaf were never large, and even in the derris treatment, where infestations were largest, no obvious signs of aphis damage were observed When the arrival of immigrant adults ceased in late July the derris sprays effectively killed any resident aphides and reduced leaf infestations in this treatment to the nil level obtaining in the other treatments. A survey of cones made at the level of the top wire in early September indicated that all treatments were free from infestation.

The plots were harvested by hand on 15th September. Yields of dry hops were as follows:

Dimefox	21·15 cwt. per acre
Demeton methyl	19·48 „ „ „
Derris	17·74 „ „ „
Least significant difference (P=0·05)	2·01 „ „ „

The dimefox treatment significantly outyielded the derris treatment by 3·41 cwt. per acre. The difference between the demeton methyl and the derris treatments of 1·74 cwt. while large, was not quite significant. The difference of 1·67 cwt. between the dimefox and the

demeton methyl treatments while also large was also not quite significant. If this last difference is real, the yield increase obtained by dimefox over demeton methyl would appear to be greater than can be accounted for by the very slight increase observed in aphis control.

The hops from the three treatments were pocketed and valued separately. No differences in physical appearance or aroma were reported, all three being placed in the Grade I class on market valuation. Analysis of samples from each plot for resin content gave the following average results:

	Alpha acids %	*Beta fraction* %	*Total soft Resins* %
Dimefox ..	5·8	7·3	13·1
Demeton methyl	5·8	6·7	12·5
Derris	5·5	6·4	11·9

These resin values fall within the expected range for Golding hops. Statistical examination of these resin figures has shown that while no significant differences occurred in the alpha acids, dimefox appeared to give a real ($P=0·05$) increase in the beta fraction over both the demeton methyl and the derris treatments.

Harvesting took place under very wet conditions. A heavy thunderstorm, which gave over 2 in. of rain was just ending as picking began. All treatments weighed badly on drying averaging 135 green bushels per dried cwt. with no observable differences between treatments. Five green bushels from each treatment (one per plot) were dried separately and the resulting hops weighed. The following average results were obtained:

Dimefox	416 gm. dried hops per green bushel
Demeton methyl	414 ,, ,, ,, ,, ,, ,,
Derris	422 ,, ,, ,, ,, ,, ,,

The observed differences were small and not significant.

(*b*) Observations on a New Systemic Insecticide

Small scale trials were carried out with a formulation of a new systemic compound, O,O dimethyl S (N-methyl carboxamide methyl) phosphorothiolothionate, marketed in 1958 under the name of Rogor 40. This formulation, while harmless to Fuggles proved to be phytotoxic to Goldings, causing severe leaf damage.

Application in early July as a spray at the recommended rate was followed within a week by marginal scorch and interveinal yellowing of the leaves. Badly affected leaves subsequently became necrotic and died.

Tests with the formulation were also carried out on 12 unnamed seedlings selected at random in the plant breeding rows. Following a single application at the recommended commercial rate, five of the seedlings developed no symptoms, two were slightly affected and five showed severe damage. These results, taken in conjunction with those already reported for dimefox (see pages 18 and 37 of the Departmental Report for 1956), emphasize the importance of thorough testing of such compounds on a *range* of varietal material before commercial release.

PATHOLOGY SECTION

REVIEW OF THE YEAR'S WORK

J. R. Coley-Smith and F. H. Beard

The work of this section during the year was entirely concerned with Hop Downy Mildew, *Pseudoperonospora humuli*.

(*a*) Hill Dusting Observation Trial

This trial was commenced in April, 1957 (Darling, Derbyshire and Beard, 1958) to investigate the effect on the incidence of Downy Mildew of dusting hills with fungicides during the growing season. Golding setts were used which were planted in March, 1957, in ground from which hills known to be heavily infected with the disease had recently been grubbed. The treatments applied in 1957 were repeated in 1958 and are being continued in 1959. These consist of captan dust or dry Bordeaux powder applied by hand to individual hills at approximately monthly intervals as follows:

(*a*) Three times per season, during April-June (Bordeaux powder only).

(*b*) Six times per season during April-September (Bordeaux or captan).

(*c*) Untreated controls.

In 1958 all hills showed the characteristic freedom of young plants from rotting of the rootstock and from basal spike, and no treatment differences were observed.

It has been suggested that the dusting of hills with Bordeaux powder may result eventually in copper poisoning of the rootstock. In 1958 the total application of Bordeaux powder in this trial was at the following rates:

Three dustings per season: 45 lb. per acre.
Six „ „ „ : 98 lb. „ „

The copper content of the proprietary Bordeaux powder used was not more than 10 per cent. (the precise copper content was not stated by the manufacturers) giving a maximum rate of copper

application in this trial of less than 10 lb. per acre per annum. This compares with the total of from 15 to 25 lb. of copper per acre which is applied annually by the standard Bordeaux mixture high volume spray programme recommended by the National Agricultural Advisory Service.

(*b*) Streptomycin and Basal Spike

As a result of recent American claims (Horner and Maier, 1957) a small replicated trial was carried out, using 192 mature hills of Eastwell Golding, to see if the application in March-April of a 1,000 parts per million streptomycin spray would give control of the basal spike form of Downy Mildew. Four treatments, each involving a total of 48 hills, were given as follows:

Early application only:	Sprayed on March 26th when shoots were 1-2 in. long.
Early and late application:	Sprayed on March 26th and again on 22nd April.
Late application only:	Sprayed on April 22nd when shoots were 4-10 in. long.
Control:	No spray applied.

The streptomycin was applied by hand sprayer to the naked crown of each hill at the rate of 300 ml. per plant. Subsequent leaf growth showed yellow chlorotic patches in the sprayed plants but not in the controls. This chlorotic effect was more marked in the plants receiving the late application.

Spikes were counted and removed from all treatments during April and May, the totals being tabulated below:

Treatment	Numbers of spikes and dates of removal				
	17 April	23 April	28 April	5 May	Total
Early application ..	16	119	218	243	596
Early and late ..	14	115	243	296	668
Late application ..	28	126	188	243	585
Control	9	118	235	292	654

No treatment differences were observed. The spikes from the streptomycin-treated hills were normal in size and appearance and produced spores freely under field conditions.

These results show that no control of basal spike was given by streptomycin.

(*c*) Overwintering of the Hop Downy Mildew

Research has started on this problem to discover how the first infected shoots (basal spikes) arise in the spring. A summary of existing knowledge on the subject is given in an article on page 88 of this report. The development of oospores in artificially inoculated cones has been studied.

(*d*) Downy Mildew Resistance Tests

The detached leaf technique used previously (Darling and Derbyshire, 1957) has given very variable results. The methods for testing resistance are being modified with a view to making comparisons of leaf, shoot, rootstock, and cone susceptibility of several varieties.

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CROP PHYSIOLOGY SECTION

REVIEW OF THE YEAR'S WORK

I. H. Williams

Growth Studies

Fundamental studies on the growth and development of the hop in the field were continued. Flower initiation and elongation in relation to climate were investigated. This work will be continued in succeeding years.

Propagation

A series of experiments were carried out to establish optimum methods for the propagation of soft wood cuttings. The use of mist techniques and soil warming equipment gave excellent results. This work was carried out in collaboration with Mr. J. T. Sykes of the Department of Horticulture, Wye College, and is described fully in an article on page 62 of this report.

Dormancy and Food Storage

Studies on the growth and dormancy of hop plants have shown that these phases of the plant can be controlled. This has enabled critical experiments to be carried out to examine the changes which occur in the utilization and accumulation of food storage materials in the rootstock at different stages of the annual growth cycle. This work, carried out in conjunction with the organic chemist, is described elsewhere on page 55 of this report.

Irrigation

A large scale irrigation experiment was carried out at Bodiam with the co-operation of the Guinness Hop Farms Ltd. The wet summer largely precluded effective irrigation, but it is hoped that this experiment will be continued for a number of years to assess the value of irrigation to hops growing in this area.

NOTES ON UNNAMED WYE VARIETIES OF HOPS IN COMMERCIAL CULTIVATION

F. H. Beard

Several unnamed seedling hops raised by Professor E. S. Salmon have been grown commercially on a small scale during recent years. Reference is made to them under their index numbers in the acreage returns published annually by the Hops Marketing Board and in the Annual Booklets of the Association of Growers of the New Varieties of Hops.

Of these, information on WFH 16, a second generation seedling of Bullion via WFC 79 raised in 1937, has already been published (Beard and Salmon, 1955a and b; Beard, 1957). It is cultivated on a very small scale (0·2 acres) by one grower in the West Midlands.

The wilt tolerant variety OZ97a, a first generation seedling of *Humulus americanus* var. *neomexicanus* raised in 1921, has also been discussed in print (Beard, 1958). Several acres of this variety are now being grown on wilt farms in the South East.

No published data on the remaining unnamed seedlings are available and to make good this deficiency relevant information for each has been assembled and is presented below in note form.

AGG8

Seedling of Brewer's Gold; raised in 1931.

Acreage:

1957-58: 22·4; 1953-56: 1·0.

General:

From the growers' point of view AGG8 is probably the most attractive of all the hops of the "Manitoba" type, with its good cone development and disease resistance. It has been overshadowed by the richer Bullion and Brewer's Gold. As well as being less rich than

these varieties it is also possibly not quite such a heavy cropper. AGG8 is now being grown on a commercial scale by a brewer-grower.

Characteristics:

Generally similar to Bullion being very vigorous; at East Malling it was the most vigorous of all varieties making with only a single bine to a string a dense wall of hops (on Butcher wirework at 7 ft. square). The cones are very similar to Bullion but better developed; are a bright green and hang well without showing any signs of "going off".

Season:

Late; can safely be left till the end of picking.

Cropping:

At East Malling (seven year mean): 22·17 cwt. per acre with a bushel/cwt. ratio of 110.

Soft Resins:

Four year mean: 5·25 per cent. alpha acids; 9·04 per cent. beta fraction.

Diseases:

Downy Mildew: only slightly susceptible. At East Malling in no season did more than three out of 16 hills have spikes and in five out of 11 seasons all sixteen hills were completely free from spikes. The cones are also resistant to the disease and no cases of rootstock injury have occurred.

Mould: It can be considered as resistant, as in the bad mould year of 1945 at East Malling it remained free of disease and was, as usual, amongst the last varieties to be picked.

Wilt: Susceptible.

Mosaic: Symptomless carrier.

Trade Comments:

1942. "Pleasant aroma, greenish, fair side"—*Brewer.*

1946. "Appearance fair, cones good with pleasing fragrance. This variety has been examined several times and while it is never outstanding it always gets a good report. The hop stands up well in this season's Wye growths (1946 was sunless and wet with gales before and at picking time) although the resin content is lower than usual"—*Brewer.*

Brewing Trials:

When compared with Kent Tutshams, as copper hop used inversely to alpha acids content, it was reported as "pleasant flavour

and mild bitter, with character". As a dry hop used at the rate of 4 oz. per barrel; at 13 days and 25 days the report was "very pleasant flavour and mild bitter". (Ford and Fletcher, 1944.)

OF27

Seedling from a German variety from Hersbruck crossed with an English male at Wye; raised in 1910.

Acreage:

1954-58: 2·2; 1953: 1·5; 1951-52: 0·4.

General:

This seedling resembles Goldings and Golding Varieties in being susceptible to Mosaic, in contrast to the vast majority of Wye Varieties which resemble the Fuggle in being symptomless carriers of this serious virus disease. Owing to lack of knowledge about Mosaic this fact was not discovered until many years after the seedling was raised. Its field assessment was delayed by failure of early trial plots at East Malling through Mosaic and it is only in relatively recent years that any true appraisal has been attempted. It is now realized that OF27 is the only variety of any merit bred by Professor Salmon which can safely be grown alongside Goldings and Golding Varieties. At the present time a plot of OF27 is being established in the Silks Golding garden at Wye. There is a small commercial planting in the West Midlands, but the future of this is uncertain.

Characteristics:

Very vigorous with long laterals; cones large, pale green, of the "Golding Variety" type but with many more petals.

Season:

Late.

Cropping:

Mean for 1922-26 at East Malling: 27·7 cwt. per acre with bushel/cwt. ratio of 91. After 1926 yields fell sharply owing to the incidence of Mosaic.

Soft Resins:

Nine year mean: 6·92 per cent. alpha acids; 10·92 per cent. beta fraction.

Diseases:

Downy Mildew: Little detailed information is available as since the advent of the disease, only very small plots of OF27 have

been grown at Wye and East Malling. However, recent observations made on hills growing at Wye indicate that it is probably as susceptible to the lateral spike form of the disease as Goldings but may be less subject to basal spikes. It is definitely liable to rootstock injury but to what extent is not yet known.

Mould: Not particularly susceptible.

Wilt: Susceptible.

Mosaic: Susceptible; the early history of the variety suggested that it might be more susceptible than Goldings, but more recent experience does not confirm this view. Experience at East Malling and Wye has shown that OF27 can be grown satisfactorily when planted remote from carrier varieties.

Trade Comments:

From 1916 to 1926 samples were submitted annually to leading brewers, factors and merchants. The reports were generally favourable though in some cases the samples were thought to have a rather strong or coarse aroma.

1932. "A really splendid side, the best of all the German crosses." *Merchants.*

Brewing Trials:

This hop has been tested in brewing trials on several occasions in the past (Lones and Grant, 1927; Thompson, 1927; Thompson, 1932; Ford, 1934). The results of these indicate that while unsatisfactory for dry-hopping, OF27 could be used satisfactorily in the copper if added in inverse proportion to its relatively high P.V. In general it was felt to be satisfactory at up to 25 per cent. replacement in the grist but not more. It is currently being tested in a further series of brewing trials organized by the Institute of Brewing, from which no results are yet available.

ON78

Third generation seedling from Oregon Cluster via M45 and OP13; raised in 1919.

Acreage:

1958: 1·1; 1956-57: 0·6; 1954-55: 0·2; 1953: 0·1.

General:

Apart from its doubtful cropping capacity the variety has much to commend it to the grower. However, with its relatively poor cropping at both East Malling and Wye it could not be recommended for general planting. ON78 was originally planted out at

East Malling in 1928 and was grubbed in 1939 on account of its low yield. Another plot was planted in 1946 in a different part of the garden. This plot which also cropped poorly was continued until the general grubbing of the garden in the autumn of 1949. In 1952 a plot was planted in the Wye Field garden at Wye and for the short while it was in existence showed little signs of improving on the East Malling cropping results. It is therefore surprising to find that under West Midland conditions cropping can be good.

Characteristics:

ON78 has the attractive pale green, well-developed and many-petalled cones typical of many of the Oregon Cluster crosses. Vigour is moderate. Laterals are long and the lower ones bear their cones rather singly. In the Wye Field plot there was, in some seasons, a yellowing and dropping of the lower leaves in early September.

Season:

Midseason—late.

Cropping:

Definitely poor at East Malling; ten-year mean, 16·02 cwt. per acre, with 18·36 cwt. per acre as the highest yield. Only a single season's figures are available for the Wye Field plot when the yield was 17·56 cwt. per acre. It has cropped better at a site in the West Midlands; the grower reports on the 1950 crop: "My acreage is only 0·048 acres but we calculated our yield to be 23 cwt. per acre which compares very favourably with other varieties. I like the hop very much from the picking point of view and cropping. I am gradually increasing my stock. I should like to go on producing this variety as it is a good keeper and seems to have a pleasant aroma."

Soft Resins:

East Malling (ten-year mean): 6·77 per cent alpha acids; 9·08 per cent beta fraction.

Wye (five-year mean): 7·07 per cent. alpha acids; 8·80 per cent. beta fraction.

Diseases:

Downy Mildew: Relatively resistant, producing hardly any basal spikes and only a low number of lateral and terminal spikes in seasons favouring this form of the disease. It does not suffer from rootstock injury.

Four-year mean of spike production at Wye: 3 basal, 46 lateral, 6 terminal per 100 hills.

Mould: Not particularly susceptible.
Wilt: Susceptible.
Mosaic: Symptomless carrier.

Trade Comments:

1934. "Fair appearance, mild Manitoba aroma, poor rub, moderate side; no particular commercial value."—*Merchant.*

1942. "Good hop, fair side, aroma pleasant but slight."—*Brewer.*

1947. "Pleasant aroma. I have re-examined ON78 alongside three samples of 1947 Goldings. ON78 is similar to a Golding. Compared with OC79 (a seedling of Brewer's Gold) it has a touch of coarseness at the back, but when compared with Goldings they are very much alike."—*Brewer.*

1954. "Appearance very nice; good colour and cones; aroma mild and pleasant not quite so delicate as Golding."—*Brewer.*

Brewing Trials:

In a trial, where Fuggle was used as control and New Varieties were used in inverse ratio to their P.V. ON78 as a copper hop gave a common flavour. As a dry hop it was found to give an unpleasant flavour (Ford, 1933).

DD12

Seedling of Bramling × male seedling (R4/25a) of *H. americanus* var. *neomexicanus*, raised 1927.

Acreage:

1955-58: 0·2.

General:

Though it produces an attractive sample and appears to have some brewing merit, there is little in the variety to attract the grower.

Characteristics:

Vigorous in growth at Wye, moderate at East Malling; cones are small and nut-like with "white" petals, not unlike Canterbury Golding.

Season:

Late.

Cropping:

Poor-fair at East Malling (light loam): 15·21 cwt. per acre (three-year mean).

Good at Wye (brick earth): 24·32 cwt. per acre (two-year mean).

Soft Resins:

Four-year mean: 7·31 per cent. alpha acids; 10·95 per cent. beta fraction.

Diseases:

Downy Mildew: During the five years that DD12 was at East Malling it was little affected by the disease. The Wye Field plot planted in 1953 had only a light to moderate incidence of spikes, the mean number for the three-year period being, 66 basal, 41 lateral and 5 terminal. Neither at East Malling nor in the earlier years of the Wye Field plot was there any evidence of rootstock infection but in the last year (1957) of the Wye Field plot, 3 dead and 3 weak hills were recorded in 40 hills.

Mould: DD12 is probably resistant, as in the bad mould year (1945) at East Malling it remained free from attack.

Wilt: Susceptible.

Mosaic: Symptomless carrier.

Trade Comments:

Dried samples have been submitted to the Trade for physical appraisal on several occasions during 1937-55. Reports on the whole have been favourable indicating an English-type aroma without any outstanding characteristics.

Brewing Trial:

In a brewing trial carried out with 1942 growths in which the Golding Variety Tutsham was used as a control, DD12 was found to be not unacceptable both as a copper hop and a dry hop (Ford and Fletcher, 1944).

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SOME OBSERVATIONS ON MAJOR ELEMENT DEFICIENCIES IN HOPS UNDER FIELD CONDITIONS

F. C. Thompson

Summary

In the past major element deficiencies in hop plants have been studied in pot-culture experiments, but under field conditions, symptoms can differ.

A field trial is described in which deficiencies of phosphorus, potassium and magnesium were studied. The symptoms developed are described and discussed in relation to the relevant soil, leaf and resin analysis data.

Introduction

The effects of deficiencies of the major mineral nutrients on the growth of the hop plant have been studied by Beard (1932) and Hewitt (1945, 1946) in sand culture, and by Zattler (1934) in water-culture. Later work at Wye, however, has shown that with the hop, a rapidly growing plant developing a large root system, growth in pot-culture can be somewhat atypical and the deficiency symptoms developed may differ from those found under field conditions.

Attention was first drawn to such discrepancies by some observations made in 1947, where certain cases of poor growth of hops in the field, associated with low values for leaf potassium and for soil available potash, produced leaf symptoms differing from those described, by the above workers, as characteristic of potassium deficiency—notably in that there was no evidence of a marginal leaf scorch.

Arising from these observations it was decided, in 1948, to study under controlled conditions the development of mineral deficiencies in the field, and through the kindness of Mr. A. J. Large a site was made available in a young hop garden at Goudhurst, Kent, planted on a piece of grubbed woodland. The hops had been planted in 1947 and in that year showed severe symptoms of leaf chlorosis and scorch, suggestive of magnesium deficiency.

Experimental

Soil

Auger examination showed the soil to be a deep, well-drained fine sandy loam. Chemical determinations of pH, and of "available" nutrients by extraction with Morgan's (1937) reagent, gave the following results:

Sample depth	pH	*"Available" Nutrient* P*	K*	Mg*
0-6 in.	5·8	0·2 VL	13 VL	8 VL
6-12 in.	5·4	0·1 VL	13 VL	6 VL

It can be seen that the soil was very deficient in available nutrients and eminently suitable for the proposed trial.

Although the garden had been limed by the grower in 1945, and an average pH value of 5·8 was found in the top soil in the trial area, in 1948, small areas as acid as pH 4·6 still occurred. The trial plots, therefore, were given further liming, to their individual lime requirements, in the winter of 1948-49.

Layout and Treatments

Duplicate eight-hill plots, testing the presence and absence of phosphorus and potassium, were laid down in 1949; each plot was divided into two four-hill sub-plots to test the presence and absence of magnesium. The rates of fertilizer application to the treated plots were 250 lb. per acre P_2O_5 (as superphosphate); 300 lb. per acre K_2O (as muriate of potash) and 110 lb. per acre Mg. (as Epsom Salts). The deficiency plots received NIL applications of the appropriate fertilizer. A uniform dressing of nitrogen at 300 lb. per acre N (as "nitro-chalk"), was applied to all the plots. Untreated guard rows were left between the plots.

These treatments were applied annually, and the trial area received no other fertilizers or organic manures during the period of the experiment.

Visual Observations

For the first two years of the trial the only symptom showing was a leaf chlorosis and scorch suggestive of magnesium deficiency.

* Expressed as p.p.m. of the element in the extract. (One part of soil to two parts of Morgan's reagent, shaking time 2 min.)

In 1949, Epsom salts did not control the appearance of the deficiency, but subsequently symptoms only appeared on the "no-magnesium" plots. The initial absence of other visual symptoms of deficiencies, and the relatively strong growth made by the hops on a soil containing very low levels of plant nutrients were striking, and no doubt due, in part, to the plants making full use of a limited supply of nutrients. It should be emphasized that the soil in the experimental area was a freely-drained light loam of considerable depth and so an excellent medium for root development.

By 1951, however, the plants on the "no-potash" plots were showing marked symptoms—mainly a down-curling and overall bronzing of the leaf—which did not appear where muriate of potash had been applied.

For the next seven years the fertilizer applications were maintained and observations were continued during the growing season. In 1956, for the first time, there was a suggestion of deficiency symptoms in plants on the "no-phosphate" plots, in that the leaves appeared smaller and of a darker green colour than those receiving applications of phosphate. Similar symptoms were recorded in 1957 and in 1958. The symptoms of potassium and magnesium deficiencies appeared regularly each year and remained consistent, but their time of onset varied somewhat with season. Thus in wet years there was little apparent evidence of deficiencies at the end of June, whereas in drier years symptoms were beginning to appear by this time.

Even under dry conditions, however, no visual symptoms of deficiencies have been recorded in the early stages of growth. It has become evident from the results of this trial, together with field observations on other known cases of mineral deficiency problems in established gardens, that the appearance of visual symptoms of mineral deficiencies in established hops does not generally occur under field conditions until the plant has made its main flush of vegetative growth towards the end of June or beginning of July. Serious deficiencies will show up during July, but if symptoms do not appear until August, it is unlikely that they will be associated with any appreciable drop in yield in that year.

The reason for this may be that the annual vegetative parts of the hop plant are developed from a perennial rootstock, which in the field, on a good and fertile soil, develops extensively and forms a reservoir of nutrients upon which the plant can draw for its vegetative growth. Under conditions of acute mineral deficiency the rootstock may be weakened and restricted, but the nutrient

reserves available can still suffice, for many years, for the initial stages of vegetative growth.

Furthermore, due to this relatively "normal" growth made in the initial stages by established hop plants under field conditions, it might be expected that the deficiency symptoms shown by hops grown from cuttings in sand-culture would differ in some measure from those found in the field. This applies particularly to symptoms of stunted and restricted growth commonly found with major element deficiencies in sand culture and to such specific symptoms as shortening of the internodes in the case of potassium deficiency.

Leaf Analysis

Leaf samples were taken from the plots, selecting the youngest fully expanded leaves, at the end of June or beginning of July in each of the years 1949-52 and again in 1957 and 1958, and analysed for mineral nutrient content. A summary of the results obtained is given in Table 1 below.

Table 1

Effect of Manurial Treatments on Leaf Nutrient Content

(Mean values as per cent. of dry matter)

Year	Leaf phosphorus		Leaf potassium		Leaf magnesium			
					Without potash		With potash	
	—P	+P	—K	+K	—Mg	+Mg	—Mg	+Mg
1949	0·42	0·45	2·55	2·75	0·48	0·45	0·35	0·38
1950	0·35	0·55	2·73	3·21	0·23	0·35	0·20	0·26
1951	0·45	0·50	2·12	3·36	0·19	0·38	0·14	0·27
1952	0·36	0·42	1·59	2·94	0·23	0·53	0·17	0·38
1957	0·38	0·43	1·71	3·40	0·60	0·84	0·36	0·54
1958	0·30	0·38	1·18	2·76	0·53	0·70	0·31	0·48

In the case of leaf phosphorus and potassium, the figures given in Table 1 are the mean values over all the treatments tested. Leaf phosphorus was little affected by the presence or absence of applied potash or magnesium, though there was a tendency for the values to be slightly higher in the presence of magnesium; applied phosphate, as will be seen, has consistently increased leaf phosphorus. Similarly leaf potassium was little affected by applied phosphate or magnesium, though the values tended to be lower in the presence

of magnesium; applied potash, however, has consistently raised leaf potassium, and the effect is much more pronounced than the increase of leaf phosphorus with applied phosphate.

With leaf magnesium, however, both applied potash and magnesium had marked effects and in Table 1, the mean values are given for the four treatment combinations. It will be seen that after 1949, applied magnesium has consistently raised leaf magnesium in both the presence and absence of applied potash, but potash has consistently depressed leaf magnesium. This effect of potash level is obviously of importance in interpreting the results of leaf analysis in cases of suspected magnesium deficiency.

A point of interest is that in 1949, the first year in which Epsom salts was applied, the treatment had virtually no effect on leaf magnesium, and in this year there was no control of visual symptoms of magnesium deficiency. In subsequent years, when Epsom salts increased magnesium uptake, visual symptoms of magnesium deficiency were controlled.

It is also noteworthy that heavy applications of superphosphate have not resulted in a greatly increased uptake of phosphorus, which supports the observed behaviour of the plants on the "no-phosphate" plots, which only towards the end of the trial have shown any symptoms suggestive of phosphorus deficiency. The values for leaf phosphorus on the "no-phosphate" plots are not, in fact, exceptionally low when considered in relation to data obtained from other manurial trials on soils of higher fertility.

In contrast the potash applications have resulted in a marked increase in potassium uptake, particularly in the latter years of the trial, when the values for leaf potassium on the "no-potash" plots have fallen to extremely low levels (2·0 per cent. K might be taken as a threshold value) and, of course, have been associated with severe symptoms of potash deficiency. There seems no doubt that the relatively high values for leaf magnesium found on the "no-potash" plots are related to these low values for leaf potassium, and under these conditions symptoms of magnesium deficiency still appeared.

Soil Analysis

Soil samples to 0-6 in. and 6-12 in. depth were taken from the plots each year in the period 1949-52, and again in 1958. Determinations were made of pH, and of "available" nutrients by extraction with Morgan's reagent, and the latter results are summarized in Table 2.

Table 2

The Effect of Manurial Treatments on the Content of Available Nutrients in the Soil

(Mean values expressed as p.p.m. in the soil extract)

Year	Sample depth	Available P		Available K		Available Mg	
		—P	+P	—K	+K	—Mg	+Mg
1949	0-6″	0·4	1·9	15	27	7	10
	6-12″	0·2	0·4	12	15	5	9
1950	0-6″	0·6	1·7	14	23	6	13
	6-12″	0·2	0·4	7	10	4	9
1951	0-6″	0·4	2·8	18	41	7	17
	6-12″	0·1	0·4	4	15	4	12
1952	0-6″	0·7	4·6	17	45	—	—
	6-12″	0·2	0·6	4	18	—	—
1958	0-6″	1·8	10·2	23	92	18	40
	6-12″	0·3	0·9	12	51	16	44

The results for the 0-6 in. samples show the expected build-up of available phosphorus, potassium and magnesium, on the plots receiving fertiliser applications of these nutrients.

The results for the 6-12 in. samples, however, show a different picture, and with the phosphate treatment there has been virtually no build-up of available phosphorus in the sub-soil over the ten-year period of the trial. Now it is generally considered that there is no movement of phosphate in the soil other than by mechanical distribution through such processes as ploughing and cultivating. In hop gardens it is customary to plough to not more than 6 in. depth, and the results of this trial would appear to provide striking evidence that lack of disturbance of the soil below this depth has prevented the heavy applications of superphosphate from influencing sub-soil available phosphorus.

Another factor associated with phosphate fixation is soil acidity, but as pointed out earlier in this paper the site was limed to lime requirement at the commencement of the trial and the heavy annual dressings of "nitro-chalk" given subsequently have raised the pH of both top and sub-soil, as shown in Table 3 overleaf, so that the effect of this factor can be discounted.

With available potassium the data for the potash treated plots in Table 2 show that although up to 1952 there has been no build-

Table 3
Soil pH Values

Year	Sample Depth	No phosphate plots	Phosphate plots
1949	0-6″	6·50	6·90
	6-12″	5·55	5·70
1958	0-6″	6·90	7·05
	6-12″	6·55	6·60

up in the sub-soil corresponding to that taking place in the top soil, by 1958 the level of sub-soil potassium has increased considerably. These results support the theory that once the fixation capacity of the top soil for potassium has been satisfied, then appreciable quantities of potassium may move down into the sub-soil.

With magnesium it is generally held that movement in light soils is relatively free, and this is supported by the data for the plots receiving magnesium, in Table 2, which show that the build-up of available magnesium in the sub-soil is comparable to that in the top soil.

The results for the plots receiving no phosphate, no potash and no magnesium, for the period 1949-52, show virtually no change, as would be expected, though the figures for available potassium, on the "no-potash" plots, are rather variable. By 1958, however, all soil nutrients show increases, but it is considered that this can be accounted for by unavoidable drift on to the "no-treatment" plots from adjoining treated plots, which has occurred in spite of guard rows, ue to cultivations and the slope of the site.

Resin Analysis

Cone samples, for resin analysis, were taken in 1957 when it was considered that conditions of acute deficiency had been established on the different "no-treatment" plots and the results obtained are shown in Table 4 below. Bulked samples were collected from the duplicate plots of each treatment combination, and a further sample was taken from a headland guard row which had received no applied fertilizers, the only additional nutrients which the plants could utilize, other than those initially present in the soil, being those transferred by drift from the adjoining treated plots. The plants in this guard row did, in fact, show acute visual symptoms of both nitrogen and magnesium deficiencies and were doubtless affected by shortages of both phosphorus and potassium as well, but symptoms of these latter deficiencies, if present, were masked by the dominant visual symptoms resulting from lack of nitrogen and magnesium.

Table 4

Effect of Treatments on Resin Content of Cones

Resins	Phosphorus		Potassium		Magnesium		"Nil"*
	—P	+P	—K	+K	—Mg	+Mg	
Total Soft Resins %	12·97	12·21	12·55	12·49	12·09	12·80	13·70
Alpha acids % ..	5·42	5·27	5·47	5·23	5·22	5·40	5·73
Beta fraction % ..	7·55	6·94	7·08	7·26	6·87	7·40	7·97

* Sample taken from headland guard row receiving no applied fertilizers.

While it would be unwise to attach great importance to the resin analysis data for one season, obtained from a limited number of samples from a small observation trial, it is of interest to consider the results in relation to those found under more normal conditions of hop-culture. Evidence to date from field manurial trials, where high and low levels of N, P, K and Mg manuring have been tested on soils well supplied with available nutrients, has shown that differences in manuring have no great influence on resin content, though the tendency is for high nitrogen to depress resins and for high potash to increase resins. In this trial the most marked effect has been the decrease in resins with applied phosphate and the increase with applied magnesium, and it may be that under conditions of acute deficiency these effects are valid. There would certainly seem to be no doubt that the high values for resins found in the guard row plants under the NIL treatment are largely due to nitrogen deficiency, since both in pot culture, and in the field with grassed-down hops, where obvious visual symptoms of nitrogen deficiency have been established, the resin content has been raised appreciably. Under such conditions, however, crop yield is seriously reduced and the yield of resins per acre falls.

Deficiency Symptoms Observed in the Field

Nitrogen

Nitrogen deficiency was not specifically studied in the Goudhurst plots but was observed in the unmanured guard rows. It is very rarely seen in commercial hops under arable cultivation, but can occur in hops grown in grass swards and is one of the major problems to be overcome in this system of cultivation.

Nitrogen deficient plants have small, pale green leaves, with bright red petioles. In severe cases growth is weak and stunted and lateral production and flowering is severely reduced.

Phosphorus

In commercial gardens, definite visual symptoms of phosphorus deficiency have not been recorded.

In field trials, where phosphatic manuring has been omitted for a number of years, the plants have developed leaves which are smaller and of a darker green colour than those found on comparable plots receiving phosphate. There is also a tendency for the leaf petioles to be a darker red, in the absence of phosphate, and for growth to be thinner. In such cases a marked yield response to phosphate manuring may be obtained.

Potassium

In the field the first visual indication of potassium deficiency is a down-curling of the leaves associated with a bronzing of the tissue between the veins. This interveinal tissue then becomes paler green in colour and eventually dies, giving rise to an interveinal scorch. The light yellowish green colour of the interveinal tissue and accompanying interveinal scorch, are sometimes difficult to differentiate from the interveinal chlorosis and scorch found with magnesium deficiency, and in such cases leaf analysis can be a valuable aid to diagnosis. In the final stages of potassium deficiency the leaves wither to an ashy-grey colour and fall.

As mentioned earlier in this paper, the hop appears to be able to make considerable vegetative growth in the early part of the season, even under conditions of acute potassium shortage, but the considerable premature defoliation which can take place later in the season in such cases can result in a marked fall in yield of hop cones. It should also be pointed out that the results of current manurial trials suggest strongly that economic responses to increased potash manuring can be obtained, where the soil is, for hops, low in available potash, even though there may be few, if any, obvious visual symptoms of potassium deficiency apparent.

Magnesium

The first visual symptoms of magnesium deficiency show up as a bright yellow chlorosis of the lower leaves which develops between the veins and along the leaf margin. This chlorotic tissue subsequently dies, but initially the dead tissue tends to be localized

between the veins while the remainder of the leaf turns yellow, so that a characteristic "tiger-striping" effect is produced with bands of yellow tissue alternating with dark brown bands of dead tissue. Subsequently the leaf withers and dies, and premature defoliation results.

Exceptionally, somewhat different symptoms have been observed, which have responded to treatment with magnesium sulphate. In such cases the dominant symptom is one of a more general leaf chlorosis with an absence of interveinal scorch and so of the characteristic "tiger-striping" effect; in contrast, with the general chlorosis type of symptom, there is a tendency, in the later stages, for a light brown marginal leaf scorch to develop. There is some evidence to suggest that these atypical symptoms may arise at high nitrogen levels.

In severe cases of magnesium deficiency, which are uncommon in hops, the first visual symptoms may appear in early July and the severe premature defoliation which can then occur can cause a marked drop in yield. Symptoms of the deficiency can fairly frequently be found developing late in the season, in mid- to late-August, but such symptoms do not appear to be associated with any appreciable drop in yield, as by this time the cones have formed and largely grown out. In fact, in contrast to potassium, where there are no marked symptoms of magnesium deficiency showing yield response to magnesium applications has rarely been obtained in manurial trials

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A NOTE ON THE RELATIONSHIP BETWEEN SOFT RESINS AND REDUCING SUGARS IN THE HOP CONE AS A RESULT OF NITROGENOUS MANURING

E. W. Weston

Summary

When clonal Fuggle N hops were grown at Wye in sand culture at nil, normal and twice normal levels of nitrogen nutrition, the soft resins content of the cones varied inversely with applied nitrogen. The relationship was most marked in the case of the alpha acids. The yield of cones and their percentage content of reducing sugars were greatest at normal rates of nitrogen application. A significant positive correlation was found between the percentage content of alpha acids and of reducing sugars.

Introduction

It seems probable that the general carbohydrate status of the hop plant affects the production of soft resins in the cone. The relationship between carbohydrate and resin is not, however, a simple one and the sand culture experiment described below was undertaken in an attempt to control growth more closely than is possible under field conditions, so that the effects of one factor only, i.e. nitrogen fertilization, could be examined.

From the results obtained from field manurial trials the effect of additional nitrogenous fertilization was to decrease the percentage soft resins in the cones. The effects, however, were small and commercially unimportant (Thompson, 1955).

It has been observed in many plants that a reduction of percentage sugars results from an increase in nitrogen fertilization. There was no reason to suppose that the hop plant would be an exception to the general rule.

The above would suggest that a positive correlation may be expected between reducing sugars and soft resins in the hop cone when the effects of different levels of nitrogen application only are considered. This was indicated by a pilot experiment carried out at Wye in 1957 (Weston, 1958) when the results were not significant.

Experimental

In order to produce deficiency symptoms at will, while at the same time producing growth capable of bearing cones in sufficient quantity for analysis, a technique of sand culture suggested by Dr. I. W. Selman of Wye College was adopted.

Clonal Fuggle N was the variety used, 21 bedded setts being planted singly in large glazed earthenware pots 10 in. in diameter and 10 in. deep. Two strings were put to each plant to a height of 12 feet and one bine trained up each string. 500 ml. of a complete nutrient solution was given daily as soon as growth began in the spring and trace elements were supplied from time to time as described in an earlier report (Thompson, 1957).

On June 2nd the sand was thoroughly washed with rainwater and three separate nutrient treatments given. These treatments were as described above except that nitrogen was eliminated from the treatment of one batch of 7 plants, twice the normal quantity of nitrogen given to another batch of 7 plants while the third batch of 7 plants continued with the normal treatment. Where nitrogen was eliminated, potassium nitrate was replaced by potassium sulphate to give the same amount of potassium in the two cases. As the plants continued to grow they gradually showed visual signs of the treatment differences. The plants receiving no nitrogen produced yellowish leaves as compared with the dark green of the high nitrogen treatment. The leaves fell more rapidly from the nitrogen deficient plants although conditions were such that all plants lost many of their lower leaves before the cones were picked. This is a common feature of hops grown in sand culture and may be due to insufficiently large pots.

Only the cones produced on plants having the normal nitrogen nutrient were well developed and of a normal green colour at the time of picking. The cones on the nitrogen deficient plants were light straw coloured and small, whereas many hops on the plants treated with excessive nitrogen had turned dark brown, possibly a symptom of wind damage.

The cones were picked from all plants on September 5th and 6th, the yield from each plant being picked into a separate muslin bag. They were dried in a small experimental kiln at a temperature of 140° F. without sulphur treatment and they were allowed to cool in the muslin bags to reach equilibrium with the normal room atmosphere, after which they contained about 10 per cent. moisture. The yields of each plant were weighed and the cones transferred to

small polythene bags in which they were stored for subsequent analysis.

Chemical Analysis

Total soft resins were determined by directly weighing the fraction extracted by petroleum ether and soluble in cold methanol. Alpha acids were determined polarimetrically in the methanol solution. The nitrogen content of the cones was determined by the Kjeldahl method and reducing sugars by Somogyi's method.

The following table gives the results obtained:

	Treatments			Significance levels	
	Nil N	Normal N	Twice normal N	5%	1%
Yield (gm.) ..	40	66	40	13·8	19·4
% α-acids	4·90	4·49	2·32	0·51	0·72
% β-fraction ..	5·96	5·95	4·10	0·60	0·84
% nitrogen ..	2·00	3·02	3·69	0·18	0·25
% reducing sugars ..	2·89	4·19	2·13	0·59	0·83

Correlation coefficient % red. sugars × % α-acids = +0·540 significant at 2% level.

Conclusions

As was to be expected the percentage nitrogen content of the cones increased significantly with increase in applied nitrogen. The percentage content of alpha acids followed the expected pattern by varying inversely with the applied nitrogen and with the nitrogen content of the cones. The percentage beta fraction also followed the same trend as the alpha acids but with a smaller range, a feature which appears quite general.

By contrast the yield of cones and their percentage content of reducing sugars did not vary consistently with applied nitrogen but were both greatest at the normal rate of application. In spite of this, a significant positive correlation was found between the percentage alpha acids and the percentage reducing sugars as has been expected. If this positive correlation resulted from manurial treatments in general as suggested by the 1957 pilot experiment at Wye, then the factors which produced the negative correlation found in New Zealand by Askew *et al.* (1954, 1958) must be sought elsewhere, possibly in terms of weather conditions.

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CHANGES IN THE CARBOHYDRATE BALANCE OF THE HOP *(HUMULUS LUPULUS* L.*)*

I. H. Williams and E. W. Weston

Summary

An experiment showing the relationship between food storage and growth and development of the shoot is described. Analysis of the storage organ has shown that the rate of carbohydrate accumulation is inversely related to the rate of growth of the shoot.

Introduction

Hops, in common with perennials and biennials generally, carry over from season to season considerable food reserves. These are largely concentrated in the portion of the shoot at or just below soil level and in the thicker roots, which together constitute all that remains of the plant over the winter period. The proportion of perennial stem to root depends to some extent upon the height to which the hill was earthed up in the previous growing season, since moisture and darkness appear to stimulate this process (Wilson, 1950). In the present paper, this portion of root and stem is referred to as the storage organ. It is what is generally meant by the commercial term of the "hill".

Although little work has been carried out in this field, it is probable that these reserves are utilized during the spring and early summer period of rapid growth and development of the shoot and may also be drawn upon during cone development. The late summer and autumn may be a period when food reserves are replenished in the storage organ to be used during the following growing season.

The length of these periods of utilization and replenishment are not known. Nor is it known to what extent this "carry-over" of food reserves influences the yields in the succeeding year. The need for this information, in connection with cultural practices, has already been emphasized (Williams, 1958). In particular accumulation of

food reserves in the autumn may be materially influenced by the manner and time of harvesting.

The present experiment was designed to examine the changes in the food reserves in the storage organ which occur when shoots are elongating vigorously and when shoots have ceased elongation and are becoming dormant but still retain their leaves.

Materials and Methods

Environmental control

Plants of the variety Eastwell Golding were grown from softwood cuttings rooted in early July. The plants were grown in pots in an unheated glasshouse until mid-August, when they were about 1 metre high. They were then moved into a heated glasshouse with a minimum temperature of 55° F. One group of plants was placed in a daylength of 16 hours, the natural daylength being extended by using combined tungsten/high pressure mercury vapour lamps. A second group was grown throughout in the naturally shortening days of autumn and early winter, at the same temperatures.

Five plants from each treatment were sampled at weekly intervals from August to December. Roots were washed out and the shoot above soil level and fine roots removed, leaving the storage organ. The length of the shoots and the total leaf area were measured at each sampling.

Chemical analysis

The storage organs were dried in a vacuum desiccator and stored for future analysis for reserve carbohydrates. The total dry weight was recorded prior to analysis. In the earliest plants in which the dry weight of the entire storage organ was less than 2 gm. the whole organ was analysed. With larger storage organs, about 2 gm. were taken for chemical analysis.

After weighing, the sample of material was ground, together with a little sand, by pestle and mortar. The powder was washed out into a 100 ml. centrifuge tube with 80 per cent. methanol and centrifuged at 2,000 r.p.m. until the solid material formed a cohesive layer at the bottom of the tube. The clear supernatant liquid was then poured off. The solid material which remained was stirred with a little more methanol solution and again centrifuged. The resulting supernatant liquid was added to the previous portion, and the combined solution made up to a known volume in a measuring flask, usually 100 ml. or 250 ml. as convenient.

This alcoholic solution contained the soluble sugars, mainly monosaccharides and disaccharides. It was analysed for reducing sugars only which were assumed to be almost exclusively glucose and fructose.

The solid fraction resulting from the centrifuging was washed into a 150 ml. flask with 66 ml. of 0·7 N. sulphuric acid and hydrolysed by refluxing for 2 hours (A.O.A.C., 1935). It was assumed that this treatment would hydrolyse all the polysaccharides which could be considered as reserve or storage material.

The sugar resulting from the hydrolysis of the reserve polysaccharides was mostly glucose; this was confirmed by determining the sugar in a typical hydrolysate using a polarimeter in addition to the oxidation technique of Somogyi (1945). This technique consists essentially of the reduction of a copper reagent by the sugar, the resulting cuprous oxide being reoxidized by a mixture of potassium iodate and potassium iodide in acid solution and excess iodine then titrated against a solution of sodium thiosulphate.

Both the original soluble reducing sugars and the product of the hydrolysis were analysed by this latter method. The sugar solutions were decolorized in both cases by shaking with a little decolorizing carbon, the hydrolysate being neutralized first by adding sodium hydroxide solution until phenolphthalein indicator turned red. The indicator was removed on the carbon so that it did not interfere with the subsequent stages of the analysis.

Results

Growth of the Shoot

Plants in the long day treatment continued to elongate and develop new leaves throughout the experiment. By late November, the plants had developed shoots between 4 and 5 metres in length. At about this stage flower initiation occurred in these plants and infertile cones were produced. Plants grown under natural short days ceased elongation in early September. Although leaves on these plants remained viable for a considerable time they gradually became senescent and the shoots ultimately died back to soil level.

Elongation and leaf area of plants in the two treatments are shown in Fig. 1.

Total Accumulation of Carbohydrate Reserves

Elongating plants in the long day treatment accumulated food reserves slowly although developing an extensive fine root system.

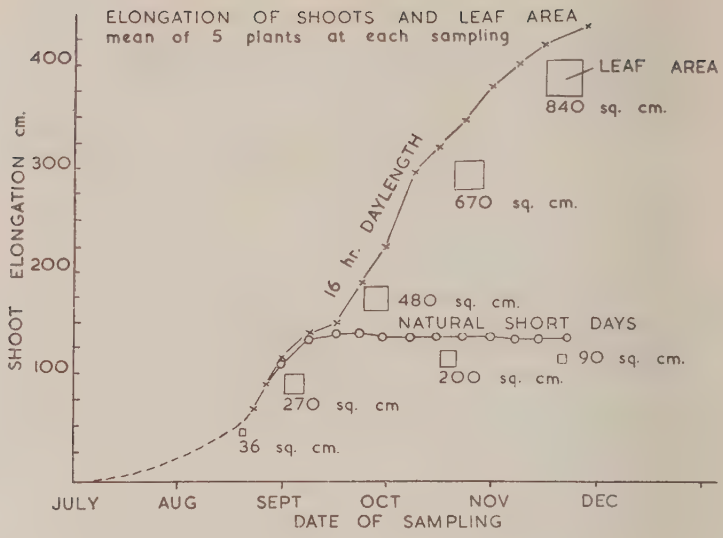

FIG. 1

The mean dry weight of the storage organ was between 4 and 4·5 gm. in late October and did not increase further although growth of shoot and root continued. Total reserve polysaccharides increased to about 1 gm. in October and remained at this level.

In contrast, when plants ceased elongation in the short day treatment there was a rapid increase in the total dry weight of the storage organ, which attained a mean dry weight of 13 gm. by mid-November. By this time few viable leaves remained on the shoots. Similarly the total quantity of reserve polysaccharides increased from 1 gm. in late September to 3·5 gm. in November. These differences are shown in Figs. 2 and 3.

Carbohydrate Fractions in the Storage Organ

The fractions of the storage organ which can be ascribed to reserve polysaccharides or to reducing sugars are given in Table 1 where these quantities are expressed as percentages of the total dry weight.

The data in Table 1 indicate that there is no apparent difference between treatments, nor is there a big variation with date of sampling in spite of the very big changes in the corresponding

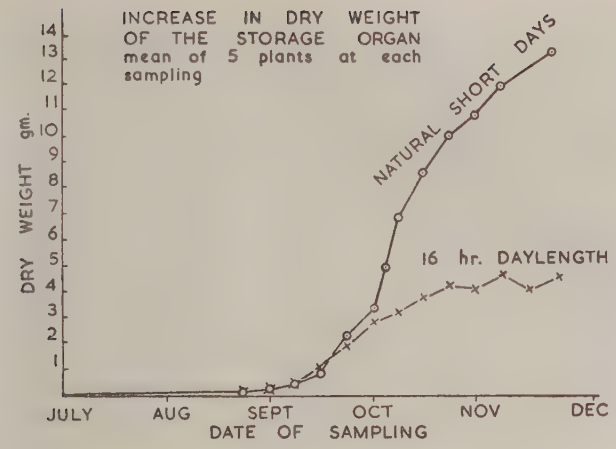

Fig. 2

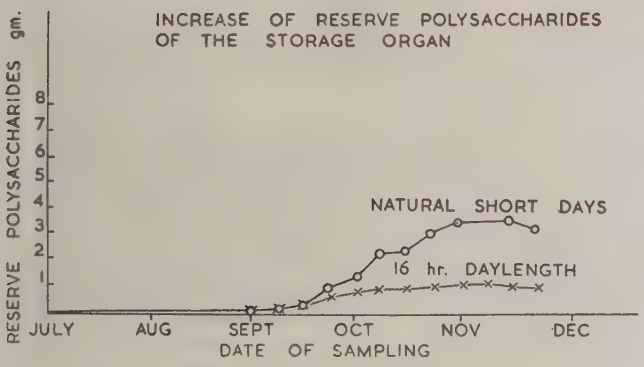

Fig. 3

weights of the storage organ. The reserve polysaccharides appear to be built up concurrently with the overall growth of the storage organ.

Conclusions

These results indicate that during periods of rapid growth of the bine there is only a very gradual accumulation of carbohydrate

Table 1

Carbohydrate Fractions in the Storage Organ of the Hop Expressed as Percentages of the Total Dry Weight

Sampling date	Natural Short Daylengths		16 hour Daylength	
	% reducing sugars	% reserve polysaccharides	% reducing sugars	% reserve polysaccharides
26.8.58	2·63	20·7	3·25	19·8
2.9.58	2·43	18·4	2·51	21·2
8.9.58	3·13	25·3	2·56	22·5
15.9.58	3·18	29·4	3·18	29·2
25.9.58	4·33	38·9	4·22	30·4
30.9.58	4·83	34·9	5·93	26·8
7.10.58	4·25	33·7	4·47	25·3
15.10.58	5·12	29·8	5·10	26·7
21.10.58	4·68	30·4	4·65	22·3
28.10.58	3·99	33·8	4·76	25·6
13.11.58	4·26	25·0	4·27	24·3

reserves in the storage organ. This experiment was carried out during autumn and early winter, when environmental conditions were relatively poor despite the use of artificial irradiation. The rate of elongation was never comparable with that of plants growing in the field in spring.

Although the long day plants developed a leaf area of five times that of the short day plants, the amount of carbohydrate reserve at the conclusion of the experiment was less than a third of that of the plants which went dormant. This is more surprising since the newer leaves developed consistently by the long day plants would be expected to be more effective photosynthetically than the visibly senescing leaves on the short day plants. It seems probable that although a higher level of photosynthesis was maintained in the vigorously elongating plants, the photosynthates were largely utilized for current new growth and the development of new shoots, leaves and roots. Since little shoot development was apparent in the short day plants a greater portion of the photosynthates were available for conversion into storage material resulting in a more rapid build-up of carbohydrate reserves.

The methods used for the determinations of soluble sugars and reserve polysaccharides were somewhat empirical. But only a broad picture of the changes taking place was attempted in this initial experiment, and simple and rapid methods of chemical analysis were desirable.

The only previous report of the polysaccharide content of hop roots is by Hautke and Zázvorka (1957). Starch content is reported to vary from 8·5 to 17·5 per cent. according to the time of sampling and previous cultivation treatment. The figures obtained in the present work were substantially higher and this could be due to the fact that polysaccharides other than starch were included in the determination.

This experiment has indicated the changes likely to occur in the carbohydrate balance of the hop during periods of rapid vegetative growth of the shoot, and periods when leaves are still present but growth has ceased. The artificial nature of the environment used means that no direct comparison with mature plants growing in the field can be attempted. Further studies are in progress to examine the behaviour of plants growing under natural climatic conditions. In particular, it is hoped this year to obtain some indication of the importance of the storage organ in relation to cone development.

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HOP PROPAGATION

II. SOFT-WOOD INTERNODAL CUTTINGS

I. H. Williams and J. T. Sykes

Summary

Previous research on the propagation of this type of soft-wood cutting is reviewed. Recent work at Wye College is described using soil warming and "mist" techniques. These have been shown to increase both the number of cuttings successfully regenerating and the rate of rooting. When used in conjunction with methods developed for growing hops under glass during its dormant period in the field it offers a means of supplying research workers with plant material throughout the year.

Introduction

Commercial methods of propagation include the use of setts and layering the bine in the field. The method of layering was developed at East Malling Research Station by Keyworth *et al.* (1948) and has been reviewed recently by Farrar (1958). By this method "60 to 70 cuttings per hill" can be obtained in one growing season. This rate of multiplication appears to be satisfactory from the viewpoint of the industry. Research, however, often requires a supply of clonal material in considerably larger numbers, throughout the greater part of the year. This is possible only by using some type of small vegetative cutting and only if plants can be kept growing in an actively vegetative state at all times of the year to supply cutting material. The present paper describes the means and equipment necessary for this type of propagation.

Review of the Literature

Bailey (1939), at Wye College, first described a method of propagating plants from soft-wood cuttings. He used two types of cutting, whole shoots pulled from hills in early spring and cuttings made from laterals taken from the lower five feet of the bine in early and mid-summer. Cuttings made from laterals consisted of a basal node from which the leaves were removed, and two or three nodes

on which the leaves were retained. These were inserted in a peat and sand mixture in a cold frame in an unheated glasshouse, the method being limited to the period of June to about the end of August. Bailey used various "root initiating substances", and claimed that these increased the "take", but the number of cuttings which successfully regenerated remained small, in the region of 8 to 10 per cent.

Beard and Wilson (1946, 1949) carried out a more extensive series of experiments at East Malling Research Station, using both basal shoots and laterals as source material and a range of root initiating chemicals. They sought a method whereby cuttings could be rooted directly into cold frames in the open. Results with the cuttings made from laterals were not successful; of over a hundred Fuggle cuttings inserted, "within a month of planting most were dead" and "all eventually died". With other varieties successful regeneration ranged from 7 to about 40 per cent. It was concluded that "these trials have shown definitely that lateral cuttings are not likely to be a success when planted directly into simple cold frames". Also, it was found that root inducing chemicals appeared to be deleterious in some varieties.

Bailey's method has continued to be used in this Department and the number of cuttings successfully established has increased considerably as knowledge and skill with this technique has improved. It has been found that ambient temperatures during the first few weeks after the cuttings have been inserted can be critical —a period of hot sunny weather at this time can destroy an entire frame of cuttings. A further drawback to this method is the considerable labour involved in "nursing" the cuttings until they are established. This can best be appreciated from the words of Professor Salmon (Beard and Wilson, 1946): "The shoots are placed 3″ deep and no 'rooting solution' is used; the lights are kept on from 10 to 14 days (according to weather), and the plants are syringed overhead once a day, if the weather is cool, and as many as three times a day in warm sunny weather. The frames are shaded by sacking when necessary. Ventilation is given gradually . . . "

The Environment and the Cutting

It seemed evident from the work reviewed that the environment during the early stages of establishment of the cutting was highly critical. Given the right conditions, the regenerative capacity of this form of cutting appeared to be high. The first series of

experiments were designed to establish optimum conditions for rooting and at the same time to reduce the amount of labour involved, by the use of more automatic control.

The Effect of Soil Warming Equipment

Comparison was made between cuttings placed in an unheated frame in a cold glasshouse and those placed in a frame with a soil warming cable thermostatically controlled to maintain the temperature of the rooting medium (1:2 peat and sand) at 70-75° F. Cuttings were made from vegetative lateral shoots collected from hills of Eastwell Golding in June; 100 cuttings were used in each treatment.

Table 1

Soil Warming

Treatment	No. established after two weeks	No. subsequently	Total regenerating %
No Bottom Heat ..	17	23	40
70-75°F. Bottom Heat	65	18	83

The effect of bottom heat was quite marked, significantly ($P=0\cdot01$) increasing both the rate of rooting (a majority of cuttings having rooted within two weeks) and the number successfully rooted.

Soil Warming Equipment and Mist

Cuttings from laterals of Eastwell Golding were set in a peat and sand mixture on the open bench in a mist propagating unit in the Department of Horticulture. This unit consisted of misting nozzles and an "electronic leaf" designed to maintain automatically the maximum turgidity of the cuttings during the rooting period.* In addition, two levels of soil warming were tried. Each treatment consisted of a hundred cuttings. Cuttings in the treatments in which mist was not used were sprayed periodically by hand and shaded in the initial stages in the manner described earlier.

* This unit consisted of a control unit designed by the N.I.A.E., Wrest Park, and ceramic misting nozzles supplied by Messrs. E. Allman and Co. Ltd., Chichester.

Table 2

Soil Warming and Mist

Treatment	Number established after 1 week	Number established after 2 weeks	Number established subsequently	Total number of cuttings regenerating %
No Bottom Heat. No Mist	0	12	28	40
70-75°F. Bottom Heat. No Mist	4	57	14	75
No Bottom Heat + Mist	0	22	29	51
70-75°F. Bottom Heat + Mist	56	26	16	98
85-90°F. Bottom Heat + Mist	0	4	55	59

This and subsequent experiments have shown that mist together with a bottom heat of 75° F. can greatly increase the number which regenerate and the rate of rooting of this type of cutting. At the same time the automatic control possible with this method greatly reduces the demand upon labour. With a bottom heat of 85-90° F. large callus tissue developed in the portion of shoot below soil level and there was failure, or delay, in the development of roots. It was evident that this temperature was too high for effective rooting. Mist was clearly more effective than hand spraying; this may be partly attributable to the fact that under the mist technique, the cuttings can be rooted in full light, whereas in the frames in which manual spraying is used, heavy shading is necessary for the first ten days to maintain turgidity of the cuttings.

Type of Cutting

Physiological and pathological research requires large batches of cuttings of a comparable age and size. Using the optimum conditions described above, namely, a bottom heat of 75° F. and a mist unit, various types of cuttings were tried. These included:

(*a*) Small sections of stem, petiole, lamina, in which no bud was present.

(*b*) Cuttings consisting of two nodes, the upper pair of leaves only being retained (Fig. 1).

(*c*) Leaf bud cuttings, the stem being split longitudinally to give two cuttings from each node (Fig. 2).

FIG. 1
Two-node Cutting

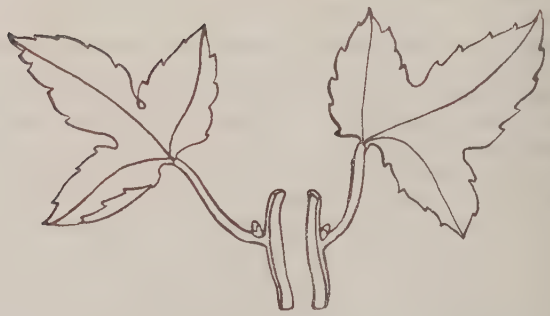

FIG. 2
Leaf-bud Cuttings

Whilst a high percentage of all types of cuttings in section (*a*) developed roots, the regeneration of a plant did not occur in a single case and it would appear that, although able to develop adventitious roots in all its parts, the hop does not readily develop adventitious buds. This limits the minimal size of cutting to type (*c*) in which one existing bud is retained. Of the two types of cuttings, (*b*) and (*c*) a majority of both rooted successfully. When potted off and grown on to supply further propagating material the two-nodal type of cuttings readily established themselves but the leaf-bud cuttings were slower and required more attention in the early stages after removal from the mist unit.

Both types of cutting produced excellent clonal material of a uniform type. The two-node cuttings are probably the most useful

size for most purposes; the leaf-bud type of cutting would be of value where a maximum number of plants may be required from a small initial stock, as in plant breeding.

All the Year round Propagation

The availability of suitable material from the field for propagation purposes is limited to the growing season. Even during this period material at different times of the season is likely to be variable. For consistent propagation of comparative, clonal material plants must be grown to supply cuttings during the entire year. This involves growing stock plants in a heated glasshouse with artificial light during part of the year. The method was first successfully established by Derbyshire and Dixon (1957) and has since been amplified. The vegetative elongation of the hop is largely controlled by the length of day. In daylengths above about 13 hours and temperatures over 55° F. hops will continue to develop leaf and shoot, whereas in daylengths below about 13 hours, even though the temperatures are maintained above 55° F., a process of dormancy is initiated, elongation ceases, leaves gradually senesce and the shoot dies back to soil level.

During the period from September to March, cuttings after rooting were grown on to supply further material for propagation in a heated glasshouse with daylength maintained at 16 hours using combined tungsten/high pressure mercury vapour lamps at 4 ft. centres 2 ft. above the plants to extend the natural daylength. Under these conditions plants continued elongating and a consistent supply of cutting material was maintained.

The rate of production of cuttings by this method was about $\times 10$ every six weeks. That is, assuming that one cutting is taken at the beginning of January it will have successfully rooted after two weeks in the mist propagation unit and if potted off and grown on in the manner described above it will develop a shoot in about four weeks from which 10 or 12 two-node cuttings can be taken for further propagation. This method thus offers a very rapid means of clonal increase.

Varietal Differences

The early experiments in 1958 were carried out with the variety Eastwell Golding. In January of this year a mist propagation unit*

* Using mist equipment designed and supplied by MacPennys Mist Propagation, Bransgore, Hampshire.

was designed and built in one of the Department's glasshouses. In addition to the mist equipment, the unit incorporates air and soil warming and additional artificial lighting. Since its installation, cuttings of a number of varieties have been successfully established and there is little evidence of any marked varietal differences in either the time of rooting or the capacity to regenerate. Varieties so far propagated include: Fuggle N, Density, Defender, Janus (for East Malling Research Station); Eastwell Golding, CC77, 16/54/14 (for the plant pathologist) and various unnamed seedlings (for the plant breeders).

Conclusions

This method of propagation will give a maximum rate of regeneration of soft-wood cuttings. By using the two-node type of cutting described large batches of standard clonal material can be obtained from plants grown under glass throughout the year. The method also offers a means of reducing the labour necessary during the initial stages of rooting since temperature, light and humidity can be automatically controlled. The overall dimensions of the unit built in the Hop Department is 6 ft. 8 in. by 3 ft. and is capable of a turn-over of three hundred cuttings every two to three weeks. No work with root promoting chemicals has been carried out since very few losses occur under the conditions of propagation described and the use of chemicals does not appear to be necessary. The problems which this method entails are mainly those of housing sufficient material for the provision of cutting material and the subsequent housing of the rooted cuttings. To maintain the flow of material throughout the year artificial lighting to extend the daylength and a heated glasshouse are needed.

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APPENDIX I

THE CHALLENGE CUPS FOR THE NEW VARIETIES OF HOPS

F. H. Beard

The fifteenth annual exhibition of New Varieties of Hops was held, under the auspices of the Institute of Brewing, at 15 Southwark Street, London, S.E.1, on November 26th and 27th, 1958. As in previous years the show was organized by Messrs. Wigan, Richardson & Co. In addition to the competition entries there were also on show samples of seven varieties of Goldings collected by Mr. David Richardson, samples of 20 triploid seedlings of Bullion Hop raised at Wye College, and also illustrations of a new "Ballot" packing for hops, and samples of the hops so packed.

Three challenge cups are competed for as follows:

(1) The Brewers' Cup, for hops intended as substitutes for American hops; this cup was presented in 1944 by Messrs. Barclay, Perkins; Messrs. Guinness and Messrs. Whitbread.

(2) The Growers' Cup, for hops intended to augment English commercial varieties; this cup was presented in 1946 by the Association of Growers of New Varieties of Hops.

(3) The Hop Merchants' Association Cup; presented in 1949 by this Association for new varieties certified as showing tolerance to *Verticillium* Wilt.

The judges were Messrs. A. J. Morris, D. G. Le May and A. E. Quin. There was an entry of 83 samples, only three less than the record entry of the previous year. A list of entries together with the analyses carried out at Wye College by Mr. E. W. Weston, is given below in Tables 1-3.

The Brewers' Cup (Table 1) was awarded to Messrs. Morphett Bros. for a sample of Bullion with an analysis of 8·7 per cent. alpha acids and 10·64 per cent. beta fraction. No second or third placings

TABLE 1

ENTRIES FOR BREWERS' CHALLENGE CUP, 1958

Variety and Grower	Parish	Hops moisture-free	
		alpha acids %	beta fraction %
Bullion (Q43)			
E. M. Gorst	Brenchley, Kent	9·10	10·37
*Morphett Bros.	Nettlestead, Kent	8·74	10·64
J. A. Worley Ltd.	Chart Sutton, Kent	8·57	9·99
Wm. Alexander Ltd. ..	Shoreham, Kent	8·52	10·45
Furnace Farms Ltd. ..	Lamberhurst, Kent	8·43	10·88
J. Nott	Kyrewood, Worcs.	7·81	9·44
John Turner	Kings Pyon, Hereford	7·72	10·80
J. F. Bomford Ltd. ..	Fladbury, Worcs.	7·68	9·71
Guinness Hop Farms Ltd. ..	Teynham, Kent	7·44	10·36
,, ,, ,, ,, ..	Bodiam, Sussex	7·12	10·02
,, ,, ,, ,, ..	Braces Leigh, Worcs.	7·11	9·92
George Nott & Co. Ltd. ..	Eardiston, Worcs.	7·06	10·09
W. D. Hukins	Tenterden, Kent	7·03	9·90
Ashdown Farm Ltd. ..	Horsmonden, Kent	6·94	9·06
Tassell Bros, Ltd.	Ulcombe, Kent	6·87	9·58
T. E. Wimshurst	Brenchley, Kent	6·69	9·71
B. P. Tompsett	Yalding, Kent	6·51	6·70
John Dinnis & Sons ..	Shoreham, Kent	6·03	8·59
Brewer's Gold (C9a)			
Raymond D. Wickham ..	Brenchley, Kent	7·57	9·36
Wm. Skinner & Son ..	East Sutton, Kent	7·24	8·77
E. L. Worsfold	Sutton Valence, Kent	6·36	8·55
Guinness Hop Farms Ltd. ..	Teynham, Kent	5·83	8·17
Pride of Kent (170a)			
J. F. Bomford Ltd. ..	Fladbury, Worcs.	7·40	11·45
Sunshine (V94)			
J. F. Bomford Ltd.	Fladbury, Worcs.	6·48	8·02
College Cluster (N15 bis)			
Guinness Hop Farms Ltd. ..	Bodiam, Sussex	5·81	6·39

* Awarded Cup.

TABLE 2

ENTRIES FOR GROWERS' CHALLENGE CUP, 1958

Variety and Grower	Parish	Hops moisture-free	
		alpha acids %	beta fraction %
Northern Brewer (WFB 135)			
George Nott & Co. Ltd. ..	Eardiston, Worcs.	9·14	8·40
John Turner	Gold Hill, Hereford	8·90	9·37
Wm. Alexander Ltd. ..	Eynsford, Kent	8·81	8·83
Wm. Alexander Ltd. ..	Shoreham, Kent	8·79	9·45
B. P. Tompsett	Yalding, Kent	8·66	8·35
Ashdown Farm Ltd. ..	Horsmonden, Kent	8·39	8·66
George Nott & Co. Ltd. ..	Eardiston, Worcs.	8·32	8·81
Wm. Skinner & Son ..	East Sutton, Kent	8·29	8·00
J. F. Bomford Ltd. ..	Fladbury, Worcs.	8·15	9·17
Tassell Bros. Ltd.	Ulcombe, Kent	8·04	7·97
H. Veall	Staplehurst, Kent	8·00	8·47
J. & P. Day Ltd.	West Farleigh, Kent	7·88	8·69
J. & P. Day Ltd.	West Farleigh, Kent	7·84	9·03
†Courage & Barclay	Hunton, Kent	7·65	7·50
E. L. Worsfold	East Sutton, Kent	7·41	8·13
E. E. Taylor & Son	Kingsdown, Kent	7·39	8·78
H. Veall & Son	Capel, Kent	7·39	8·55
G. A. & S. G. Calcutt ..	Cranbrook, Kent	7·27	8·12
J. A. Worley Ltd.	Chart Sutton, Kent	7·22	7·46
J. & P. Day Ltd.	West Farleigh, Kent	7·11	8·65
Guinness Hop Farms Ltd. ..	Bodiam, Sussex	7·11	8·19
James Day Ltd.	Yalding, Kent	7·02	7·79
John Dinnis & Sons ..	Shoreham, Kent	6·68	6·94
A. & K. J. Amos	Wye, Kent	6·42	7·49
J. Nott	Kyrewood, Worcs.	6·22	8·72
Pride of Kent (170a)			
H. Veall	Capel, Kent	7·23	12·09
W. D. Hukins	Tenterden, Kent	6·46	11·46
A. & K. J. Amos	Wye, Kent	6·18	11·19
Early Choice (FF21)			
*J. F. Bomford Ltd. ..	Fladbury, Worcs.	5·21	6·37
Copper Hop (OK40)			
J. F. Bomford Ltd. ..	Fladbury, Worcs.	6·61	8·14
ON78			
J. F. Bomford Ltd. ..	Fladbury, Worcs.	6·05	7·79

* Awarded Cup. † Placed second.

TABLE 3

ENTRIES FOR HOP MERCHANTS' ASSOCIATION CUP, 1958

Variety and Grower	Parish	Hops moisture-free	
		alpha acids %	beta fraction %
Whitbread Golding Variety (1147)			
*Whitbread & Co. Ltd. ..	Yalding, Kent	6·69	6·84
D. H. J. Britcher	Marden, Kent	5·98	6·97
†C. M. Fox Ltd.	Yalding, Kent	5·61	7·47
Anthony Coleman	Goudhurst, Kent	5·49	6·74
‡J. & P. Day Ltd.	West Farleigh, Kent	5·32	7·42
James Day Ltd.	Yalding, Kent	5·31	6·69
J. & P. Day Ltd.	West Farleigh, Kent	5·29	7·20
J. & P. Day Ltd.	West Farleigh, Kent	5·29	6·13
G. A. & S. G. Calcutt ..	Goudhurst, Kent	5·03	6·83
J. A. Worley Ltd.	Yalding, Kent	4·97	6·81
C. E. & W. S. Millson ..	Goudhurst, Kent	4·74	6·97
Bramling Cross (OT48)			
D. H. J. Britcher	Marden, Kent	7·79	7·94
B. H. Day Ltd.	Marden, Kent	6·85	8·28
Bob Ward	Biddenden, Kent	6·48	7·78
C. E. & W. S. Millson ..	Goudhurst, Kent	6·21	8·39
J. & P. Day Ltd.	West Farleigh, Kent	6·13	7·01
J. & P. Day Ltd.	West Farleigh, Kent	5·78	7·00
J. A. Worley Ltd.	Yalding, Kent	5·37	7·88
James Day Ltd.	Yalding, Kent	4·79	6·52
J. A. Worley Ltd.	Yalding, Kent	4·68	7·78
Keyworth's Midseason (OR55)			
E. L. Manwaring	Yalding, Kent	6·52	6·57
Guinness Hop Farms Ltd. ..	Bodiam, Sussex	6·04	7·44
J. & P. Day Ltd.	West Farleigh, Kent	5·73	6·16
D1 (*Density*)			
B. H. Day Ltd.	Marden, Kent	4·52	7·31
D3 (*Defender*)			
Whitbread & Co. Ltd. ..	Yalding, Kent	5·53	7·73
J2 (*Janus*)			
Whitbread & Co. Ltd. ..	Yalding, Kent	4·76	5·98
OZ97a			
B. H. Day Ltd.	Marden, Kent	3·68	9·94

* Awarded Cup. † Placed second. ‡ Placed third.

were made in this class. The general level of the analyses for this cup and for the Growers' Cup was very similar to that of the previous season and definitely of only moderate richness.

The Growers' Cup (Table 2) was awarded to Messrs. J. F. Bomford Ltd. for a sample of Early Choice with an analysis of 5·21 per cent. alpha acids and 6·37 per cent. beta fraction, which was the lowest analysis in this class. A sample of Northern Brewer from Messrs. Courage and Barclay was placed second. The above two samples were, in the opinion of the judges, nearest to an English aroma. Their opinion was that the sample of Northern Brewer was outstanding, with a very good English aroma and they would have placed it first had it been free from "blight". The awards for this year's competition clearly show the relative importance in the trade of aroma as compared with resin content, at any rate where English type growths are concerned.

In the competition for the Hop Merchants' Association Cup all three placed samples were of Whitbread Golding Variety, a complete reversal of the previous year when they were all Bramling Cross. This competition is still very much a contest between the above two varieties. Keyworth's Midseason is on the way out, while the East Malling varieties Density, Defender and Janus, together with the Wye variety OZ97a, are as yet only grown on a very small scale. Until the acreage of these varieties increases they are unlikely to provide serious competition. The production problems, particularly those of drying, militate against the production of first class samples from small plantings. The Cup was won by a sample from Messrs. Whitbread & Co. Ltd. with an analysis of 6·69 per cent. alpha acids and 6·84 per cent. beta fraction. Placed second and third were samples from Messrs. C. M. Fox Ltd. and Messrs. J. & P. Day Ltd. Although the judges preferred the samples of Whitbread Golding the samples of Bramling Cross had the higher average analysis. It is interesting to note that the cup winner had the highest alpha resin of the variety. Incidentally the mean level of analyses in the competition for this cup is rather higher than last season.

APPENDIX II

HOP CULTIVATION AND HOP REGIONS IN THE WEST MIDLANDS

D. C. D. Pocock, B.A.
(*Demonstrator in Geography, Nottingham University*)

Introduction

A geographical approach to the regional study of hop-growing was suggested in last year's Annual Report (Pocock, 1958) when a survey was made of hop cultivation in south-eastern England. This article is a study of Herefordshire and Worcestershire, England's second hop-growing area. Acreage trends since the early nineteenth

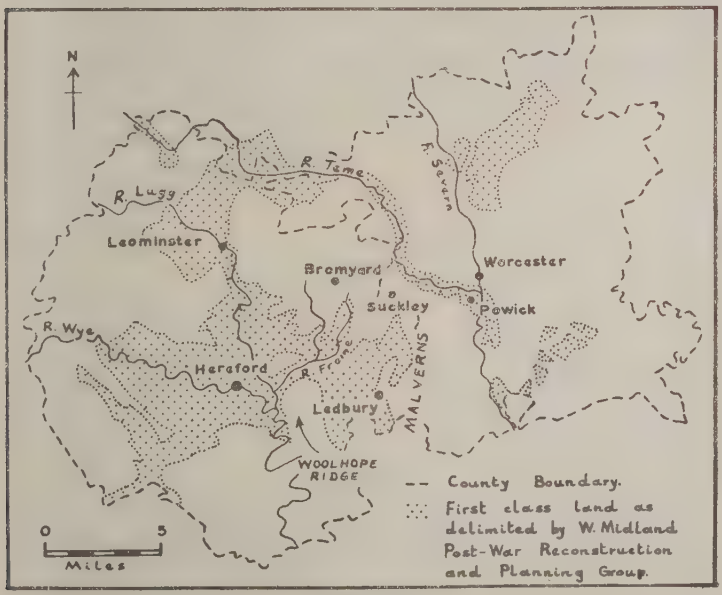

Fig. 1

century are described only where these differ from those of the four south-eastern counties. The distribution of hop-acreage and division into hop regions are discussed before concluding with some comparisions between the two main producing areas in this country. A general map of the two West Midland counties is given in Fig. 1, showing places mentioned below in the text and indicating the distribution of first class soil.

Pattern of Hop Acreage

The nineteenth-century acreage pattern of the West Midlands is different from that of the south-eastern counties, which rose to a peak acreage total in 1878 as a result of the hop duty repeal in 1862, only to be followed by a precipitous decline. The West Midlands' hop-acreage, after a decline in the first part of the century, continued to rise till 1894, and showed significant decline only after 1901. From 1878 to 1916 south-eastern England's acreage declined by 58 per cent., but the West Midlands' by under 2 per cent. Consequently the latter area doubled its relative importance compared with the South-east, from 11·9 per cent. of the national acreage in 1878 to 23 per cent. in 1916 (see Fig. 2).

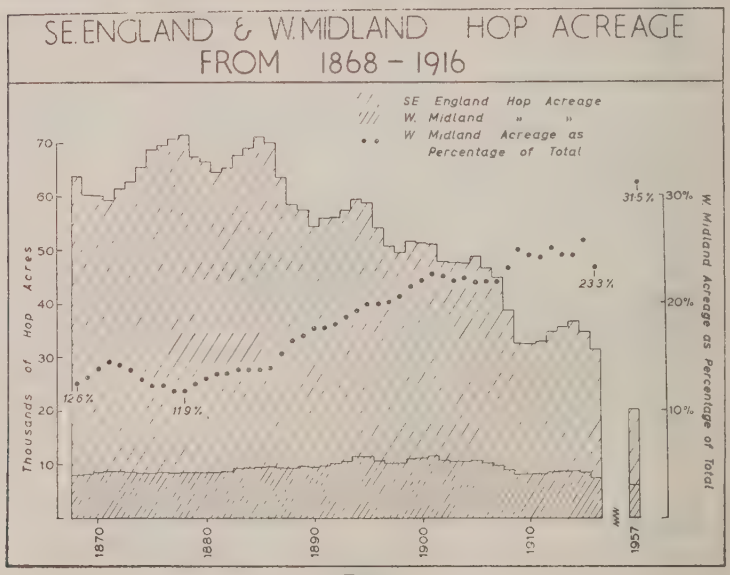

Fig. 2

The West Midlands' stability reflects that region's earlier adoption of quality hops and greater attention to cultivation and drying. Large acreage increases of heavy cropping coarser varieties were not a post-1862 feature of this area. Whitehead (1890) wrote: "there has been more improvement in the condition, quality and general appearance of hop samples produced in these two counties within 25 years than in any other hop district", remarking that "brewers have taken a fancy to 'Worcesters' ". The West Midlands also produced their hops more cheaply in the period prior to the first world war because of lower land values and earlier use of horse-teams, factors recorded first by Whitehead (1882) and later by Parker (1934).

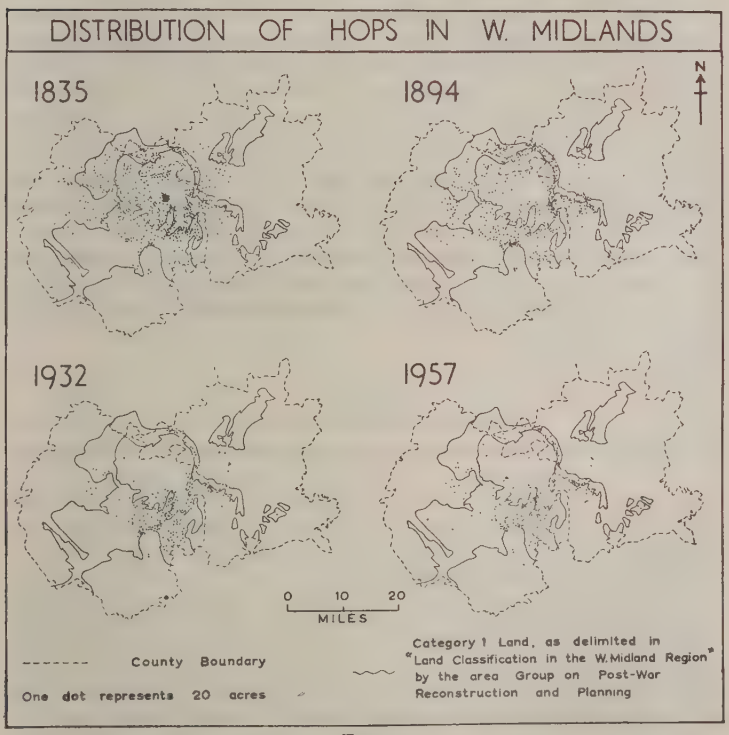
DISTRIBUTION OF HOPS IN W. MIDLANDS
1835
1894
1932
1957
N
0 10 20
MILES
County Boundary
One dot represents 20 acres
Category 1 Land, as delimited in "Land Classification in the W. Midland Region" by the area Group on Post-War Reconstruction and Planning

Fig. 3

Distribution of Hop Acreage

Fig. 3 shows the distribution of hop acreage in relation to the area's first class soils for four significant years. 1894, and not 1878, was the year of maximum acreage in the West Midlands, but otherwise the years are those which were used in the study of south-eastern England (Pocock, 1958).

The crop's most extensive cultivation occurred in the first half of the nineteenth century when a relatively even distribution covered a wide area. The important concentration at Bromyard at this time is probably exaggerated by the registering at Bromyard of pockets brought in from nearby parishes. Present day hop cultivation exhibits a more direct relationship with the area's better class soils.

In all four maps one can see a concentration of activity along the Teme Valley (with a branch towards Worcester) southwards to near Ledbury, where the area widens out before swinging westwards to Hereford. Definite cessation or contraction of hop-growing has taken place on the eastern (heavy red Keuper Marls) and north-western margins (high areas of drift-covered soils, although this ought not to be over-stressed for some wide areas of first class land also occur). The high, dissected plateau of Dittonian sandstone with its coarse soils north of Bromyard has lost almost the whole of its once widespread activity. The Woolhope Ridge, to the east of Hereford, and the Malvern Hills, astride the boundary between the two counties, provide obvious barriers in the south of the hop-growing area. All these features are summarized in Table 1 and in Fig. 4.

Table 1

Acreage Density of Hop Regions

No.	Hop Region	Acres per square mile			
	Name	1835	1894	1932	1957
1a	E. Herefordshire Core	36·9	35·2	32·9	36·0
1b	W. Worcestershire (Teme Valley) Core	34·8	43·8	28·2	31·5
2	Middle Lugg—Upper Teme ..	29·4	19·0	3·4	4·9
3a	NE. Herefordshire Upland ..	29·7	9·5	0·7	0·5
3b	E. Marginal	14·5	4·3	2·2	1·6
3c	Malvern Foothills	29·4	15·0	2·2	1·1
3d	SW. Marginal	6·6	6·4	1·2	1·2
3e	NW. Marginal	20·5	8·5	0·5	—

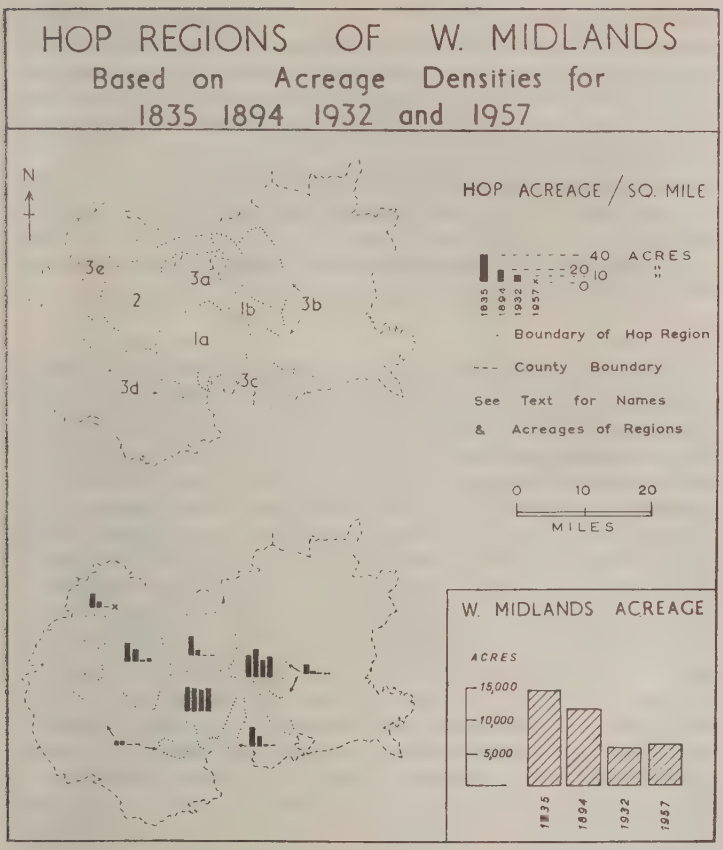

Fig. 4

Hop Regions

The dominance and stability of the core regions, 1a and 1b, is evident. Today they contain three-quarters of the West Midlands' total acreage and are the only two regions with sizeable densities. In 1835, however, hop-growing was comparatively evenly distributed, and regions 2, 3a, c and e possessed densities only slightly lower than the two core regions. The East Herefordshire region (1a), the historic centre, roughly between Hereford, Bromyard and Ledbury, benefits from drift-free soils derived from the Downtonian division of the Old Red Sandstone, and, to a less extent, alluvium.

In the Teme Region (1b) to the north hop yards are largely concentrated on fertile river terraces, and to the south on soils developed on Downtonian and Keuper series in a broader zone south of the river between Suckley and Powick. 1b is the only region to show an increase in hop-growing between 1835 and 1894. Region 2, similar physically to 1a, covers a large area and possessed more widespread cultivation up to 1894, but now has a density only only one-sixth that of the two main regions. This figure, however, is greater than the peripheral regions (3a—e), none of which shows any increase since 1932 and which today possess only a few scattered hop yards.

Conclusions

In summarizing the above study it is of interest to compare significant features of hop-growing in the West Midlands with those of south-eastern England. Firstly, it should be stressed that both the areal extent and acreage-density of hop gardens of the latter area have always been much larger than in the West Midlands. For instance, the present East Herefordshire core density is only three-quarters that of the Mid Kent core. Moreover, no region in the West Midlands has ever exceeded a density of 44 acres per square mile, whereas 120 acres per square mile has been recorded in south-eastern England. Secondly, the two main hop regions in the West Midlands have established their dominance more through the decline of hop-growing in surrounding areas than by their own acreage increases. In the South-east, on the other hand, the main regions have participated in any acreage fluctuation on a grander scale than surrounding regions; indeed, they have been largely *responsible* for these movements. Finally, the present leading regions of both the West Midlands and south-eastern England are in areas with favourable soils, and have retained their status as the main centres of production throughout the past 120 years. Marginally located regions, often in areas with less favourable physical conditions, are now unimportant despite former relatively high densities.

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APPENDIX III

THE 1958 HOP SEASON
WEST MIDLANDS REGION

G. P. Chater
(*Hops Advisory Officer, West Midland Region, N.A.A.S.*)

The past season was one of the most difficult for many years but in spite of the difficulties the final outcome was a very heavy crop, harvested in reasonable time, of better quality (P.V.) than the two previous crops. After a relatively normal autumn and early winter during which work progressed well, February was again a very wet month. March and April were dry and good tilths were obtained easily and growth progressed steadily. May, June and July were relatively wet months and although August had rather less rain than normal, the number of "wet days" was excessive, and at the end of the month over 100 acres of wirework, mainly in the Hereford District, collapsed. Finally, September, the month of harvest, had many periods of very heavy rain and a total rainfall of 7 in., the highest for many years.

The annual quota had again been set at 116 per cent. of the basic quota and growers made every effort to have all acreage at full plant. This resulted in hop setts reaching very high prices and unfortunately the demand far exceeded the supply of "Certified" material.

The introduction of a mechanical spinner to remove the earth after ploughing down, may eventually take away the heavy manual work involved in exposing the crowns of the stocks for dressing in row work. It is hoped that modifications and experience will improve its performance and prevent the damage sometimes seen at present.

Pests and Diseases

Precautions against the possible spread of Progressive *Verticillium* Wilt on or from Rosemaund Experimental Husbandry Farm

were continued. At present there is no reason to suppose that either of the existing yards at Rosemaund have this disease or that there is any other outbreak anywhere in the West Midlands.

Downy Mildew basal spike was common in most yards in the early spring. Lateral spikes and infected leaves threatened serious infection throughout the season and, with spraying operations continually hindered by wet weather, control was most difficult. Aerial spraying was used on many acres but only as a supplement to normal applications of copper sprays and dusts. Widespread infection of the cones took place during the early part of August, but with cooler weather and repeated spraying the spread of infection had stopped by the time picking commenced. Nevertheless, a considerable acreage of hops was badly attacked and although machines tend to discard diseased hops so improving the sample's appearance it would have been better if some acres had been left unpicked. Most propagation beds were seriously infected and many young setts showed root infection.

Powdery Mildew was more widespread than usual but was generally controlled before damage had reached severe proportions.

The Aphis attack was comparatively slight but migration to the hop continued until late in the season. The build-up in the cones was quite rapid and many yards were heavily infested, but so late in the season that little damage was observed in the samples.

Hop Root Weevil has continued to be troublesome in some yards. A recent experiment has conclusively proved the superiority of Aldrin dust over B.H.C. dust for the control of this pest.

Nettlehead and Mosaic (virus) caused considerable anxiety in the early part of the season due to the increased spread but no further increase was observed during the season.

Hop Picking

In spite of the exceptionally wet conditions when gateways and headlands were just "seas of mud" picking was generally completed within the month. Approximately 30-32 per cent. of the growers in this region now have picking machines but over 82 per cent. of the acreage is machine picked. Some machine-picked growths have been valued as equal to the best hand-picked samples but some growers again included too much extraneous matter. The grade prices show a very wide variation with some diseased samples valued at little more than a quarter of the average price. Difficulties in preserving the colour of very wet hops during drying were

experienced, at times, by most growers. A continuous belt drier and a two-tier system were installed near Worcester. The belt system has a number of difficulties to overcome but under expert management a considerable quantity of hops was effectively dealt with during the season. The two-tier system will no doubt be improved with experience and a more direct approach to complete mechanization of this method of drying.

APPENDIX IV

THE 1958 HOP SEASON: SOUTH-EASTERN REGION

CATHERINE L. JARY, B.Sc.(Hort.)
(*Hops Advisory Officer, South-Eastern Region, N.A.A.S.*)

IN south-eastern England the summer of 1958 was one of the most unpleasant in living memory, but the final yield and quality of the hops were surprisingly high. The only substantial period of settled weather occurred in the last week of April and the first part of May. Thereafter the rest of the summer was predominantly wet and cool, except for another period of ten dry days in early September. Exceptionally heavy rain occurred in the latter part of June and again in August and mid-September. In June flooding in the Low Weald was worse than in most winters and quite unprecedented for that time of year. The most violent of the August storms missed the main hop area but the relatively few gardens in the Farningham area suffered severely. In spite of the season, however, the high quota of 116 per cent. was slightly exceeded and although the increase of 400 acres contributed to the result, it nevertheless shows that hops can stand excessive rain better than drought.

PESTS AND DISEASES

The first unusual occurrence of the year was an exceptional (and unexplained) outburst of Mosaic among the Goldings and G.V.'s (except Whitbread's G.V. which is not sensitive to Mosaic). In several cases rogues of carrier varieties (often Fuggles) were found to be acting as centres of infection. Such carriers can go undetected for a long while, until something of this kind induces growers to search for them. Nettlehead, while still troublesome, was less severe than in recent years. Split Leaf Blotch was very prevalent. In view of the seriousness of this disease which has recently been demonstrated by workers at East Malling, growers would be well advised to pay more attention to it than hitherto. Aphis attack

was only moderate and easily controlled, although in some cases the use of dimefox as a rootstock application accentuated the damage from water-logging in June. Downy Mildew was present in its various forms throughout the whole season, and the cones were also attacked by Botrytis, giving the typical "nose-rot" which was very prevalent, and not controlled by any of the normal sprays. There was a marked swing towards low volume spraying (35-50 gallons per acre) and this appeared to be comparable in efficiency with the conventional high volume, possibly because it enabled growers to get round their hops more frequently. Towards the end of the season a substantial acreage was sprayed from the air, but the effect was difficult to assess. While in most cases it was done too late for maximum effect, there were comments about the uneven distribution of the copper deposit. Mould was not a problem.

It was a very bad year for *Verticillium* Wilt, not only for the progressive form but also for Fluctuating Wilt which is always associated with wet conditions. In such circumstances, it was more than usually difficult to distinguish between severe Fluctuating and an early outbreak of Progressive Wilt.

Several new outbreaks of Progressive Wilt are reported or discovered each year, and both 1957 and 1958 brought to light more than the average number. Taking the two years together, 36 new farms were found to be infected, of which 35 were in Kent, and one in Surrey. As might be expected, the greatest increase occurred in the High Weald on the fringe of the most heavily infected area. Although several farms there have been infected for some time, it has still been possible to grow Fuggle as the main variety, and under these conditions further spread was inevitable. In Kent this area lies along the south-west border extending from the parishes of Chiddingstone, Penshurst, Leigh, Tonbridge and Hadlow, south-eastwards to Rolvenden. Surprisingly, no new outbreaks have been reported from the adjoining parishes of East Sussex from Frant to Northiam. In the most heavily infected area of mid-Kent where the progressive form of wilt originated, practically every farm is already infected; Fuggle has virtually disappeared and has been replaced by wilt-tolerant varieties.

The total number of known wilt-infected farms is now—Kent 250, Sussex 13, Surrey 2. (The Surrey cases are in the centre of the county well away from the Hants/Surrey hop area and one of the farms is not now growing hops.) In Kent, 9 of the outbreaks have occurred in the "clean" area, in a chain extending from the Medway estuary in north-west Kent, eastwards and south-eastwards to

the end of the hop area beyond Canterbury. This district, which grows almost exclusively Goldings and G.V.'s is separated from the rest of the Kent hops by the North Downs, and although often described as "East Kent" does not correspond exactly with the official East Kent area of the Hops Marketing Board. These outbreaks have been eradicated by widespread destruction of the hops and grassing down of the infected areas. One new suspected case is being followed up and the possibility of a "leakage" of wilt into the north-west corner is being investigated.

In addition to the new farms quoted above, there is also some spread of wilt to other gardens on farms already infected, but this is more difficult to assess.

Several cases occurred of the breakdown of wilt-tolerant varieties. One earlier case of breakdown had been studied by East Malling for some years, but in 1958 a survey revealed breakdowns on 10 farms where at least 10 per cent. of the wilt-tolerant varieties showed symptoms but did not necessarily die. This was no doubt a result of the exceptional season, but was nevertheless alarming to the many growers who now rely entirely on wilt-tolerants. The acreage of these varieties increased by 200 acres in 1958, and now amounts to over 1,300 acres. Growers on wilt farms are once again in a dilemma; they have been warned that the market for G.V.'s is limited, and consequently the acreage of Whitbread's G.V. is not capable of indefinite expansion, while Bramling Cross has been discouraged by substantial devaluation. Hope now centres on the three East Malling varieties—Density, Defender and Janus, which are being intensively propagated, and will be available in the winter of 1959-60.

Picking and Drying

There were no major changes in either sphere during the year, but more picking machines are installed each year; there are now 240 in the South-eastern Region (Hants, Berks, Surrey, Sussex, Kent). Improved devices for the picking of laterals were introduced in both types of machine and appeared to improve performance in this most difficult part of the process.

The effect of machine-picking on the spread of wilt-infected material is causing some concern in view of the wide range of plants which are now known to take up the fungus. In the early days of machines, the picked bines were handled separately from the rest of the waste, and could be dried and burnt, thus disposing of the

greater part of the inoculum. With the increasing use of bine shredders, however, this material goes into the general pile which is very difficult to burn. Such material will not heat sufficiently in composting to destroy the fungus and thus constitutes a considerable risk, if used on susceptible crops.

While a few more kilns were adapted for two-stage drying, the main developments were towards higher air speeds in conventional kilns and conversion to oil-firing.

APPENDIX V

OVERWINTERING OF *PSEUDOPERONOSPORA HUMULI* (MIY. AND TAK.) WILSON, THE CAUSAL ORGANISM OF DOWNY MILDEW DISEASE OF HOPS: A SUMMARY OF PRESENT KNOWLEDGE

J. R. Coley-Smith

In any year the first visible stage in the annual cycle of Downy Mildew disease of hops is the production in March or April, of systemically infected shoots ("basal spikes") from the rootstock. These typically consist of thick stemmed rosette-like growths with downturned yellowish or silvery grey brittle leaves bearing on their abaxial surfaces, and occasionally on their stems and stipules, grey or black masses of sporangiophores and sporangia, the summer reproductive stage of the fungus. Such infected shoots usually remain stunted and ultimately decay if left on the plant. Basal spikes vary in size from less than an inch to a foot or more in length, the later formed ones being in general the longest.

Normally, basal spikes are not numerous enough to cause a shortage of healthy shoots for training, but they are thought to constitute the first rung in the ladder of infection in any season and as such they are very important. Control of these infected growths is thus very necessary in order to reduce infective material in the early part of the season.

The origin of basal spikes has been a much discussed problem in the past, and since work on this aspect has recently recommenced here after an interval of many years, it is proposed to review our present knowledge of the subject.

There are several ways in which basal spikes could possibly arise:

(i) By the presence, in rootstocks of infected hops, of a perennial mycelium of the Downy Mildew fungus, the mycelium invading developing buds and shoots in the spring.

(ii) By infection of buds in the previous autumn by zoospores from sporangia washed down from the aerial region, the

resulting mycelium remaining dormant in the infected buds until spring.

(iii) By germination of oospores in spring producing zoospores which infect shoots as they grow through the soil or just after they have emerged.

(iv) By the existence in soil of a saprophytic mycelium of the Downy Mildew fungus.

Ware (1926) found *Pseudoperonospora humuli* present in winter in the pith, phloem, and cortex of nursery "setts", and in several cases, in the cortex of the roots. The fungus was easily recognized by its characteristic haustoria which are formed abundantly in stems and rootstocks of infected hops. Ware was not able to demonstrate hyphae penetrating a bud although he discovered mycelium thickly massed at the bases of the buds, reaching as far as the brown bud scales. In one sett, mycelium was present in two-year-old as well as one-year-old wood.

There is no evidence for or against the theory that basal spikes arise from buds infected by zoospores in the previous autumn. It is not yet known whether buds can be infected by zoospores in the autumn nor whether following such infection, mycelium could remain dormant in them throughout the winter.

Oospores are formed far more frequently than is generally supposed. They occur in infected leaves, stems, and principally in the cones, where they are usually produced in large numbers in autumn. Many oospores must be present in hop gardens in the immediate post-harvest period.

Germination of oospores was first reported by Arens (1929). He observed germination of naturally overwintered oospores on water agar. A short germ tube was formed bearing a terminal sporangium which produced zoospores. Arens did not say how many oospores he germinated in this manner.

Bressman and Nichols (1933) germinated oospores on moist filter paper and in water. The oospores were obtained from two-year-old leaves of herbarium specimens and were germinated after grinding the material with a pestle and mortar. Germination was of the type previously described by Arens.

The only other report of oospore germination was that of Magie (1942) who stated that he germinated them in the supernatant liquid taken from water suspensions of soil. Germination occurred at temperatures of 5-20° C. after wetting periods of four to sixteen days. He also says that a dormant period of several months was necessary before oospores could be induced to germinate.

There is no evidence for the presence in soil of saprophytic mycelium of *P. humuli* and since the fungus cannot be grown on artificial media this possibility seems extremely remote.

Discussion

It is obvious that there are many conflicting ideas on the origin of basal spikes in the spring. In general it can be said that Ware's (1926) work favours the theory that basal spikes are produced by the action of a perennial mycelium of the Downy Mildew fungus and this reflects the most commonly held opinion in this country. The occurrence of such a perennial mycelium in *P. humuli* is by no means unusual, being a frequent phenomenon in the Peronosporaceae (Melhus, 1915). An argument which has been raised against the presence of a systemic perennial mycelium as the cause of basal spikes is that healthy and diseased shoots often arise from the same plant, sometimes even from the same node. This is also a feature of potato blight, caused by a very similar fungus (*Phytophthora infestans*), where the parasite overwinters in this country as mycelium in blighted tubers which may produce both healthy and diseased shoots in the spring.

Continental and American workers have described the germination of oospores of *P. humuli* and the general opinion on the continent and in the U.S.A. appears to be that this accounts for basal spike formation. It must be pointed out, however, that the oospores were germinated under laboratory conditions and it remains to be proved that such germination can occur under field conditions. Even if oospores do germinate in the field there is as yet no evidence to show that this could bring about the formation of basal spikes. In this Department and elsewhere in this country it is believed that this problem can by no means be regarded as solved.

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